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ABSTRACT

Part 1 of a three-part volume for research and development (R & D) systems researchers, this report attempts to provide a basic understanding of the process of contextual analysis for research, development, and innovation. The term "research development and innovation" (RD & I) is used to describe the total process of innovation of which R & D is only a part. Chapter 1 discusses the nature of and bases for a contextual analytical approach to RD & I and describes the comparative contextual analysis framework developed here. The contextual analysis is intended to be a framework for comparison that reveals differences or commonalities in RD & I systems across sectors. A sector is defined as a field of interrelated activities such as the fields of industry, aerospace, or education. The context of RD & I is defined as the totality of features (or significant aspects) of RD & I. A contextual analysis rests on the assumption that each feature affects and is affected by all other features. Chapter 2 analyzes the features that make up the total context of RD & I. These features are environmental influences; historical development; institutional base; goals, policies, and strategies; administrative processes; personnel base; funding; information flow; innovations; and functions. Identified as functions of RD & I are need identification, generation or research, development, production, marketing or dissemination, acquisition, implementation or utilization, support services, and evaluation research. (Author/JM)

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CENTER FOR THE
INTERDISCIPLINARY STUDY
OF SCIENCE AND TECHNOLOGY

Northwestern University
Evanston, Illinois

Research, Development And Innovation: Contextual Analysis

Part One

December 1977

Michael Radnor
Harriet Spivak
Durward Hofler

EA 011 570

RESEARCH, DEVELOPMENT AND INNOVATION:

CONTEXTUAL ANALYSIS

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PREFACE

For students and researchers from a variety of sectors concerned with R&D processes, systems and issues, the existing literature represents a bewildering and potentially misleading collection of disconnected fragments. The materials that are to be found are derived from a blend of research and wisdom-based sources that come out of various sectors (much of it industrially based -- though increasingly from other sectors such as education, health, etc.), that are rooted in very different conceptual schemes and which come from the viewpoints of a variety of disciplines. Such theories that do exist tend to deal with very limited ranges of variables and to shut out consideration of other potentially important sources of variance. There is little or nothing to guide the researcher as to the degree to which theories or technologies developed in one situation (or context, as we will define it) are relevent or appropriate in others.

Thus, one of the pressing issues for those concerned with the study of R&D is the need to build and integrate the various fields of R&D system studies. To meet this need will require:

1. an understanding of the nature, structure and functioning of R&D systems as they interact with their environments;

2. in light of the above, an understanding of the applicability (or non-applicability) for R&D in any one sector of the R&D models, technology and experience to be found in other sectors;

3. as is implied in the above, an understanding of the basis for comparative analysis of R&D systems across sectors.

It is to the above tasks which this report is addressed, bringing to bear an interdisciplinary R&D perspective of members of the research team at the Center for the Interdisciplinary Study of Science and Technology at Northwestern University (CISST).

Two separate volumes have been prepared with these tasks in mind. This volume is for R&D systems researchers, elaborating the contextual analytical framwork and methodology and exploring its utility for identifying research issues and generating research agendas. This is done through illustrative contextual analyses of four R/D&I sectors and three issues. A second volume (Radnor and Hofler 1977) will be for policy analysts and policy makers, describing the methodology in a manner useful to meet policy needs and illustrating the utility of the contextual analytical framework by presentation of policy analyses we have conducted for a number of agencies.

In addition to these general concerns with R/D&I* systems and issues, some special attention has been given to the educational sector and to R/D&I problems faced by the National Institute of Education, the funders of the research and policy studies leading to these volumes. This is reflected in the large number of policy studies described in the second of the previously mentioned volumes and in two additional volumes exclusively devoted to educational R/D&I. Thus, the third volume of the series (Spivak and Radnor 1977) is directed to the educational R/D&I community, providing a comprehensive analysis of the key aspects of the educational R/D&I system (Spivak and Radnor 1977). The fourth volume (Radnor, Hofler and Rich 1977) addresses a particular issue, the dissemination and exchange of information in educational R/D&I.

This present volume will include the following:

Chapters One and Two will provide a basic understanding of the process of contextual analysis for R/D&I.

> Chapter One will discuss the nature and bases for a contextual analytical approach and then will describe and discuss our comparative contextual analysis framework.

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*Research, Development and Innovation (R/D&I). As will be discussed in Chapter One, we use this term to describe the total process of innovation.

Chapter Two will then expand the discussion of the major aspects (which we will call "features") of an R/D&I context.

Chapters Three through Seven will then provide illustrative detailed analysis of the contexts of selected sectors, using the developed analytical framework.

Chapter Three will focus on the education sector, and will summarize the discussion presented in more comprehensive detail in the volume by Spivak and Radnor (1977) noted above.

Chapter Four will focus on the civilian aviation sector.

Chapter Five will focus on the health sector.

Chapter Six will focus on the criminal justice sector.

Chapter Seven will provide a summarized illustration of a cross-sectoral comparison of these four contextual analyses.

Chapters Eight through Ten will illustrate how the contextual analytical approach may be used to analyze specific R/D&I issues.

Chapter Eight will focus on the institutional bases of R/D&I systems, with particular attention being given to how the R/D&I functions* are "clustered" together within and among the institutions of R/D&I systems.

Chapter Nine will focus on the issue of entrepeneurship as this relates to the historical and current state of development of R/D&I systems.

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*The specific meaning we attach to the term "R/D&I functions" will be discussed in Chapter One.

Chapter Ten will focus on issues relevant to implementation/ utilization.

Chapter Eleven illustrates the use of the contextual analysis framework for policy analysis. Brief summaries are provided of policy analyses CISST has provided for NIE and other agencies.

Chapter Twelve concludes this volume with a review of the use of contextual analysis.

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Earl C. Young and Raymond Buckley were major contributors to the initial phase of the research program and to the writing of earlier versions of various materials. Others who contributed at that point were Myron C. Block and Rachel Wasserman. We wish to take this opportunity to express our appreciation for their valuable efforts. The roles of Earl C.Young and Raymond Buckley were recognized in an April, 1977 volume that reported on some of this work in its earlier forms. Their contribution is still to be seen (as will be noted) in several chapters of this volume. Since they were not able to continue working on the project, the materials that now appear are, except as noted, totally the responsibility of the authors of this book with the assistance of various members of the research team at the Center for the University. In addition to Earl C. Young and Raymond Buckley, this included Robert D. Hamilton III, William Hetzner, Robert Howard, Thomas Pipal, Atul Wad and Barbara Collins.

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CHAPTER ONE

THE COMPARATIVE ANALYSIS OF RESEARCH, DEVELOPMENT AND INNOVATION SYSTEMS: AN OVERVIEW

THE COMPARATIVE ANALYSIS OF RESEARCH, DEVELOPMENT AND INNOVATION SYSTEMS: AN OVERVIEW

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CHAPTER ONE

THE COMPARATIVE CONTEXTUAL ANALYSIS OF RESEARCH, DEVELOPMENT AND INNOVATION SYSTEMS: AN OVERVIEW

I. INTRODUCTION

One of the central issues in education is the need to develop our knowledge and skills in educational R&D policy making and management. To respond adequately to this need requires at least the following:

1. an adequate description of educational R&D as it currently exists;
2. identification of those aspects of R&D which are generic; i.e., which are in some way common across different sectors or fields (e.g., health, education, aerospace, etc.) -- if indeed such generic characteristics do exist;
3. identification of those aspects of educational R&D which are sectoral; i.e., specific to the nature of education and educational R&D (and why);
4. determining, in light of the above, why educational R&D systems have the character they do and function or operate in the ways in which we observe them to do.

When the above analyses are made and interacted with each other, we can begin to gain insight into policies and strategies which are specifically relevant to educational R&D, while at the same time allowing relevant transfer of R&D management technology and experience from non-educational sectors.

This project focuses primarily on the second of the above points (though one of our sectoral analyses will be of education). That is to say, the task of this project is to develop the outline of a framework for comparative analysis which will enable us to understand observed differences and/or commonalities in R&D systems across the various sectors. It is further the task of this project to demonstrate the utility of such an analytical frame-

work in terms both of policy making and management and of transfer of relevant technologies and experience across sectors.

Policy making and management in R&D must sail the narrow straits between Scylla and Charybdis , with the danger of non-relevant generalizations on the one side and the danger of reinvention of well-established principles on the other side. At present, there does not exist the analytical framework for R&D which could map this narrow channel for policy making/management navigators. It is our hope to provide at least the basic outline of such a map.

II. SOME INITIAL CONSIDERATIONS

Before beginning to develop a framework for comparative analysis of R/D&I systems, it is important to provide some initial background concepts and understandings from which we will be working.

1. Research, Development and Innovation -- R/D&I as a Total Process of Innovation

From this point on, we will be using the term "Research, Development and Innovation (R/D&I)" instead of the more common term "Research and Development (R&D)." Our reason is simple. The term "R&D" tends to imply a very narrow part of the total spectrum of functions and activities involved in a total process of innovation. Research and development are essentially "pre-user" aspects of the total innovation process. A total innovation process also includes such "post-development" functions such as production, dissemination (a key linking function) and acquisition/implementation/utilization (user functions). A total innovation process also recognizes that users may also be innovators.

Thus, a complete conceptualization of an R/D&I system (i.e., a total innovation process) requires that we recognize it as spanning the total knowledge production (KP) to knowledge utilization (KU) spectrum. Thus, this total spectrum of R/D&I activities will include not only research (both basic and applied) and development, but also production, dissemination, acquisition, implementation, utilization, evaluation research, etc. Further,

we must also have an understanding of the operative conditions that exist within and affect the R/D&I system (e.g.: the state of system maturity; the personnel base; funding levels and patterns; etc.). Finally, we must also take into account the environment with which the R/D&I system interacts.

Such a complete conceptualization of a total innovation (R/D&I) process recognizes the many variations of innovation processes -- for example: the role of "creative insight" by an individual apart from any research or development (e.g.: by an educational practitioner); or that a specific function (e.g.: research) may in practice exist in a rather isolated fashion. However, conceptualization of a total R/D&I process will enable us to evaluate the overall role and effects of such various types of innovation activities.

Thus, we will use the term "R/D&I".

2. The Process for Developing a Comparative Analytical Framework

The process we have used in developing the comparative analytical framework to be presented here has been an iterative process. Thus, the relevant literature and the extensive experience of CISST personnel and Northwestern University was used to make a "first cut", tentative identification of key variables (which we will later label as "features") which would seem to be common (generic) to R/D&I systems. From these key variables (features) we developed the comparative analytical framework which we are now describing. In turn, this framework was used for a more detailed and systematic examination of several sectors and of several features (and sub-parts of features).

The above process, though described in rather linear fashion, was quite iterative -- with each part of the process being repeated several times as new insights and understandings were gained. For ease of presentation

here, we will generally use a step-by-step descriptive process which reflects the results of these iterations.

3. The Emergent Nature of Real-World R/D&I Systems

It is important to note at the outset that a "real-world" R/D&I system emerges as an interactive "working out" of generic R/D&I characteristics within a specific sectoral context -- whether by deliberate design or not.

Thus, both the researcher and the decision maker must understand that R/D&I system features, issues and management policies/strategies will have both generic and sectoral dimensions, and that these will all be in interaction with each other.

For the decision maker, the importance of understanding this "emergent" nature of R/D&I systems is threefold.

1. An understanding of the generic characteristics of R/D&I systems enables the decision maker to "zero in" on the areas of the sectoral context where the critical issues are likely to be and where in-depth analysis of the sectoral context is needed.

2. An understanding of the nature and uniqueness of one's sectoral context provides a basis for learning from R/D&I systems in other sectors and for determining the adaptability/transferability of knowledge, methods, techniques, innovations, etc., from R/D&I systems in other sectors.

3. From an understanding of the interaction between generic and sectoral characteristics, the decision maker has a basis for developing policies and strategies which are both generically functional and sector-specific.

For the purposes of this study, the "emergent" nature of R/D&I systems will allow us to make cross-sectoral comparisons of R/D&I systems. To the degree that R/D&I system issues and characteristics have common aspects across sectors, we may identify generic characteristics of R/D&I systems. Contrarily, to the degree that R/D&I system issues and characteristics vary across sectors, we will have begun a description of the sectoral R/D&I system characteristics.

We may further note that this "emergent" perspective permits both deductive and inductive analysis. That is, we may start with the generic understanding of the R/D&I context (i.e., the features), and through interactive analysis with the sectoral context, identify "real-world" issues, policies, strategies. Or conversely, we may analyze a "real world" issue, policy or strategy (e.g.: the impact of specific program selection) in the light of sectoral and generic R/D&I system characteristics.

4. Some Key Terminology

It will be helpful at this point to introduce briefly some key terminology we will be using throughout this report. We will save fuller explication for later.

A. Sector -- A field of interrelated activities/institutions (e.g.: health; industry; aerospace; law enforcement; education) which is identifiable as such for practical purposes (e.g.: for funding, policy decisions, analysis).

Of course, there will be sub-sectors within a sector (e.g.: the drug sub-sector of the health sector). Also, there will be institutions which may span several sectors (e.g.: communication equipment for several sectors).

Thus, definition or delineation of a "sector" may vary according to the practical purposes of the policy maker, researcher, etc.

B. Feature -- An identifiable aspect of the total R/D&I process which is useful for analytical and/or decision making purposes (e.g.: the R/D&I system's environment; the personnel base; the network of institutions; research; development; dissemination; utilization; etc.).

C. Function -- A specific type of R/D&I system activity which describes what the system does to produce and utilize knowledge and which may thus be considered an integral part of a total innovation process (e.g.: development; implementation). The various functions form a sub-set of the total set of features.

D. Issue -- A specific aspect of a feature which is of concern to the researcher, analyst, policy maker or decision maker (e.g.: "sources of information" as a specific aspect of the information flow feature).

E. Context -- The total set of features which provides an interactive framework within which a feature or an issue must be analyzed. Thus, for example, if a specific function (e.g.: development) is to be analyzed, its context would include all other features.

5. A Theoretical Framework as an Access to Analysis

It is important to understand that all R/D&I systems consist of a complex variety of features which must be understood individually and in interaction before a full understanding of an R/D&I system as a whole can be developed. It is this very complexity which makes necessary the development of an analytical framework within which this complexity may be analyzed. At the same time, we must emphasize that the analytical framework we are presenting is, precisely, a tool for analysis. Thus, in presenting an analytical framework, we make no claim for its completeness, absoluteness, or definitiveness. Rather, in its form and content, the analytical framework is presented as a useful way of gaining access into an analytical process -- not as some esoteric "model to end all models".

Specifically, we would note the following.

A. The Listing of Features

We have selected nineteen "features" to form the basis of an analytical framework*. Different names could be given to these features; different features could be emphasized; slightly different modifications of the nature of a feature could be made; other features could be added. Indeed, we assume that a different listing of features and/or issues will at times be useful as new insights are gained and/or as features not included here have significant relevance to a specific analysis or policy issue. The way we have categorized the features should facilitate such modifications in the total list of features and issues.

B. R/D&I System Configurations

In presenting our analytical framework, we will use a linear array of the R/D&I process. This is done solely for ease of presentation. As will be seen, we fully recognize (indeed, we emphasize) the interactive, often non-linear nature of the different features (both in theory and in reality) of the total R/D&I process. The array of features (and in particular the functions) presented here could be re-labeled, subdivided, clustered, organized in parallel streams, connected with various feedbacks and cyclical loops, etc. Thus, our use of a linear array of features is simply an artifact of presentation -- and the reader should treat it as such.

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*See pages 25 - 27.

C. The Configuration of Functions: An Emergent Dependent Issue

It will perhaps be helpful here to carry this discussion of configurations a little further, specifically with respect to R/D&I system functions.

A variety of configurations of R/D&I system functions is not only possible -- such variety actually exists in and indeed may be mandated by the specific nature of the environment and operative system conditions existing within a specific sector. Thus, in some instances, we might find the various functions rather precisely segmented. In yet other instances, we might find the entire R/D&I process occurring within a single institution, or even within a single person.

Further, we might find R/D&I systems interacting with each other. Thus, a specific real-world organization (e.g.: a federal R&D laboratory; a book publisher) may play roles in several different sectors (e.g.: health; energy; etc.).

Thus, while we utilize a linear array of R/D&I functions for purposes of presentation, we will treat the configuration of functions as an emergent dependent issue.

III. R/D&I SYSTEMS: SECTORAL DIFFERENCES AND GENERIC COMMONALITIES

1. Defining a "Sector"

We have up to this point identified a "sector" in terms of a somewhat vague (but hopefully somewhat reasonable) concept of a "field of interrelated activities/institutions" (e.g.: the health field; the education field; the field of industry; etc.). The typical question we will be posing is: How do R/D&I systems vary across sectors?

There are several problems with this question. We lack any substantial

basis for knowing how or why to distinguish one sector from another -- and there are very obviously also major differences within what we call sectors. Thus, there may be greater similarities between some of the regulated industries and various government agencies than between regulated industries and other industrial firms. Service firms operate in quite different ways from manufacturing firms. Some hospitals are private for profit; others are public. And so on. If we take a purely empirical perspective and examine the R/D&I systems across the commonly differentiated sectors (industry, health, education, etc.) we quickly encounter the problem of having to deal with many unexplainable variances within sectors and across supposedly similar sectors. We also encounter similarities across supposedly different sectors. As we attempt to unravel these anomalies we inevitably move toward the use of more complex typologies of organizations, sectors, products, personnel, etc., specific recognition of historical developmental phases; consideration of differences in the state of knowledge and technology; etc.

Indeed, precisely because the definition of a real-world "sector" is an imprecise science, it is necessary to take into account the various complexities involved. Utilized in its fullest possible way, the analytical framework we are presenting would merely take this process of ever-increasing complexity to its logical conclusion. Needless to say, we are not advocating such an unfeasible ultimate strategy.

2. The Necessity of a Sectoral Basis of Comparison

To abandon a sectoral basis for comparative analysis simply because of the inherent degree of vagueness and complexity might be theoretically interesting. It would not be useful.

Society is organized and operated within such sectors to an important degree. If we are to be helpful to policy makers, managers and other participants we must be able to relate ourselves to the affairs of such specific sectors. Thus, our objective will be to attempt to understand, in relation to any specific issue under investigation, what complex of contextual conditions

has what impact; and to which sector (or part of a sector) such a complex of conditions can be associated.

We do not, for example, make the a priori assumption that the R/D&I flow of personnel will vary across all systems, or at all times within a sector such as health, education, agriculture, industry, etc. Rather we wish first to know what contextual conditions influence this flow, and then to determine in what ways sectors (or parts of sectors) vary across these contextual conditions.

In this way it will be possible to explain why similarities and differences in personnel flow appear across and within sectors. With this perspective we can also now hope to address ourselves to the question of how and why differences do appear for a given area over time. Inevitably this makes the process of comparative analysis complex, but, we believe, for the first time feasible.

3. Existing R/D&I System Variations

In attempting to develop a theoretical analytical framework for R/D&I systems, one is immediately struck by the immense amount of observable variety in real-world R/D&I systems. Existing R/D&I systems vary in such matters as: clusterings of functions within a single organization (or even within a single organizational unit); existence and strength of institutional networks; overall level of system maturity; susceptibility to political influence; types of dissemination mechanisms and strategies; use and effectiveness of various management technologies; etc.

R/D&I systems vary across sectors. Thus, for example, the R/D&I system in aerospace differs significantly from the R/D&I system in education. But the issues are complicated even further because R/D&I systems also vary within a single sector. Thus, for example, within the private industrial world we encounter rather different R/D&I systems for the oil and T.V. industries. In health, the R/D&I systems for drugs and surgical procedures will vary.

A. Illustrations of R/D&I System Variations Across Sectors

To illustrate the kinds of problems and issues that arise from such intra/inter-sectoral variances, let us look very briefly at the ways in which R/D&I functions are organized (in groupings or separately) in the real-world institutions which are to be found in the various sectors -- i.e., comparing how a variety of functions (research, development, dissemination, etc.) are encompassed in single or multiple organizations or organizational units, and how this differs across sectors. Given the present concern within education with institution building, this would seem to be an important issue for educational R/D&I.

We will briefly look at the organization of functions in the following three sectors:

1. Industry -- specifically the civilian aviation industry;

2. Health -- specifically the drug field;

3. Education -- specifically the curriculum and materials area.

In the civilian aviation industry the R/D&I system is organized in a relatively linear, function-to-function process from basic knowledge production (KP) to knowledge utilization (KU). The R/D&I system is relatively highly differentiated and each organizational unit or department is highly specialized. The stages of the R/D&I system are well developed and clearly defined. The functional clusters to be observed are those built around adjacent sets on the KP to KU continuum.

In the drug field we do not find such linear, function-to-function organization. Rather, we encounter "loops", with functions from the knowledge production stages being associated with production, implementation and utilization functions, all within single organizations. Most specifically, medical

practitioners are found having significant roles and influence at many stages of the process.

In the world of education, and specifically in curriculum and materials development and utilization, we observe a system that is characterized by highly diffused arrangements of R/D&I functions. There is a considerable amount of grouping of functions to be observed, with elements of applied research sometimes linked (sometimes not) with development and utilization. There are often gaps, with R/D&I functions being subsumed (but not articulated) into other functions.

B. Some Additional R/D&I System Sectoral Variances

R/D&I systems frequently are not sectorally "pure". Thus, a specific organization may be playing roles for a number of fields. For example, a publishing company may be involved in producing materials used in the worlds of health, education, law enforcement and business. Such sector-spanning institutions may play an important cross-sectoral linkage role, as well as playing the specific role that they do in a given sector.

We may also note that a given sector may contain several relatively distinct R/D&I systems.

4. Commonalities Among Existing R/D&I Systems

In spite of the immense amount of observable variety among existing R/D&I systems, these systems nonetheless do also seem to exhibit common characteristics -- characteristics that imply the existence of generic features of R/D&I systems.

From a broad, overview perspective, we may note that all R/D&I systems involve some rather basic, common functions, such as research, development, production, dissemination, utilization, etc. The specific form, manner or configuration of these functions may vary across sectors, but the functions themselves appear to be inherent in the overall innovation process of an R/D&I system.

We may further note that for any single R/D&I function, there appear to be characteristics which are common (i.e., generic) to that function both across and within sectors. For example, the basic research function involves a high level of uncertainty and unpredictability; involves extending the limits of the existing state of the art (a criteria for "excellence" in basic research); often involves a long time-line (10,20, even 50 years). These characteristics, if indeed generic, have strong implications for policy making and management in R/D&I systems.

In contrast, the function of development involves a significantly lower degree of uncertainty and unpredictability; is concerned with utility and "product specifications" instead of "ultimate" qualities; requires less highly specialized and more interdisciplinary personnel; and generally tends to have a short to moderate time-line (usually at least 3 to 5 years, sometimes longer). These characteristics, if indeed generic, will have strong implications for policy making and management in R/D&I systems -- but the implications will be significantly different from the implications relevant to basic research. Further, these differences between the basic research and development functions (and other functions as well) will have strong policy making/management implications concerning the integration/coordination/orchestration of the various R/D&I system functions.

5. Sector Vs. Generic: The Need for a Framework for Comparative Analysis of R/D&I Systems

The discussion thus far begins to indicate the type of questions and issues which are important to policy making and management in R/D&I systems. For example:

> How can we identify when cross-sectoral differences represent significant gaps and/or inappropriate states (i.e., the absence or wrong application of key generic aspects of R/D&I) -- and when do these differences represent reasonable adaptation to specific sectoral contexts?
>
> Why do certain management approaches (e.g.: PERT) seem to work well in one sector (aviation) and poorly in another (education)?

What policies and management approaches are most appropriate to a given R/D&I function in a specific sectoral context?

To answer such questions, it becomes necessary for us to try to understand how the requirements for R/D&I systems emerge from the interaction between generic characteristics of R/D&I systems on the one hand and the specific sectoral R/D&I context on the other hand. We must then try to understand how generic commonality and sectoral variety in R/D&I systems lead to varying policy and management issues and requirements within and across sectoral R/D&I systems.

Developing such an understanding has come to be recognized as one of the most critical needs of innovation studies at this time. In a recent review of current knowledge on technological innovation, Kelly and Kranzberg[1] have commented (based on the commissioned contributions of a dozen leading researchers in this field):

> "The literature on organized innovation consists largely of narrowly-focused, piecemeal, non-cumulative empirical studies. Hence the complex interrelations among organizational structure, function, and orientation toward R&D are not well understood.
>
> There is a critical need for higher-level, integrative theories and models which can guide the empirical studies and lead to cumulative results, both explanatory and normative. We see an immediate need for an iterative, interactive relationship between theoretical and empirical research...."

6. Three Central Questions of this Analysis

From the discussion thus far, it becomes obvious that there are really three basic questions around which this analysis is (and must be) focused:

1. Can R/D&I systems be described in <u>generic</u> terms?

2. Can an analytical framework be developed which will enable us to identify and differentiate between generic and sectoral characteristics of R/D&I systems?

3. Will the analytical framework and subsequent generic and sectoral descriptions be useful to the policy making/management decision makers? That is, can the generic/sectoral descriptions be brought down to policy and management relevant levels of detail, and yet still be mapped back into the more general analytical framework?

Real-world R/D&I systems reflect the variety and complexity that results from the interaction of generic and sector-specific dynamics. Thus, generic R/D&I characteristics cannot be identified simply by cataloguing real-world R/D&I institutions, processes, characteristics, issues, etc. -- now by creating empirically based models of R/D&I systems. Both processes lack mechanisms (analytical frameworks) with which to distinguish between that which is generic from that which is sector-specific.

Thus, what is needed is such an analytical framework, which will allow one to distinguish between the generic and sector-specific characteristics and issues of real-world R/D&I systems. This framework must recognize that the context of an R/D&I system is the product of a complex interaction of all system features and of generic and sectoral dynamics.

A framework which included a complete description of all possible contextual features and issues (and their interactions) would be quite complex -- and far beyond the scope of this study. Nonetheless, we shall attempt to provide the outline of such a framework and provide some illustrations of its usage.

In light of the above comments, we believe that a cross-sectoral method of analysis will provide an analytical framework within which generic and sectoral issues may be identified, differentiated and illustrated in a manner useful both to the analyst and to the decision maker.

It is to this task that we now turn.

IV. A FRAMEWORK FOR COMPARATIVE ANALYSIS OF R/D&I SYSTEMS

1. The Perspective of General Systems Theory

The framework presented here for the analysis of R/D&I systems has been drawn from the general systems theory literature, as exemplified by such authors as Ludwig Von Bertalannffy[3], and James G. Miller[2]. Without attempting to present an exposition of this perspective, we simply note that we have adopted the central elements of their framework for describing the structure and functioning of living systems.

Thus, we will attempt to analyze R/D&I systems in terms of how they interact with their environments; their central elements or sub-systems; the mechanisms that link them together; internal system structures; input-output systems -- as well as such other system conditions as age and state of developmental maturity.

A. System Definition

An important question is that of system definition: What is to be considered within the R/D&I system(and within which part of the system) and what is in the environment? The framework we are presenting does not contain abrupt boundary notions. What is considered within or external to the system is a matter of degree and will depend on the focus and purpose of the analysis. Further, an R/D&I system may be "defined" either broadly or narrowly, depending upon the contextual situation and the needs of analysis. In the broadest sense, a particular R/D&I "system" may (for practical purposes) comprise most of a sector. In the narrower sense, a single institution may encompass virtually all aspects of an R/D&I "system". In the latter instance, we may indeed find several institutional R/D&I "systems" existing within (and being a part of) a larger R/D&I "system" within a particular sector.

The critical point to be noted here is that the framework for comparative analysis of R/D&I systems being suggested here is not meant to be limited to a rigid conceptualization about boundary notions, size or scope of what is/is not an R/D&I system. Rather, the definition of the relevant R/D&I systems (as is true of all other aspects of the analytical framework) is based on creating an opportunity to frame key questions related to the focus of the issue analyses relevant to policy/decision makers and researchers.

B. Innovation and Operating Systems

While we have just noted that we do not want to imply rigid boundary conceptions of what is and is not "within" an R/D&I system, it is equally important not to make the boundaries of an R/D&I system so broad and/or vague that the R/D&I system includes "everything" (and thus becomes a meaningless concept). Thus, it is important to distinguish between those aspects of a sector which deal in some way with a process of innovation (and thus are a part of a total R/D&I "system") and those aspects of a sector which are not involved in a process of innovation (and thus are not part of a total R/D&I "system"). These latter aspects of a sector may be called the "operating system". Nevertheless, we will need to be aware of ways in which the "operating" system affects (or is affected by) the "R/D&I" system.

In light of the previous discussion of system definition, we should note here that the extent of "overlap" between the R/D&I and operating systems may vary significantly across sectors. Thus, for example, the effort to land a man on the moon in the 1960's involved virtually all aspects of the system in the process of innovation. In contrast, in the health or agricultural sectors, there is a large operating system which may indeed be involved at times with an innovation process but whose primary role is clearly at the "operational" level.

C. Extent of R/D&I System Linkage

Another aspect of the "system" concept that must be considered here is the extent to which the various institutions within an R/D&I system are (or are not) coherently and strongly linked together. Simply put, while we do consider a set of institutions to comprise an R/D&I system (because of the roles they play within the total process of innovation), we do not presume that they are in fact coherently linked together in "appropriate" ways or that existing linkages are strong. Indeed, the opposite may be true in any given context - - and there may be "gaps" in the system's linkages. Indeed, the critical issues here are precisely the nature, strength and appropriateness of the linkages (or lack thereof) which do exist.

D. Maturation (State of Development)

It is important that we understand R/D&I systems from an "organic" perspective. That is to say, that they "emerge" over time, that they go through/ may be at different stages or levels of development (maturation). Further, different institutions and/or different functions within an R/D&I system may differ in terms of their respective stages or level of development. The importance of this concept of maturation may be seen in at least the following ways:

1. The needs of an R/D&I system may be different when the system is young and immature than when it is established and mature.

2. Since R/D&I systems may mature (or decline) over time, their needs may change over time.

3. Policies, strategies and mechanisms which are relevant for an R/D&I system which is young and immature may be irrelevant (even dysfunctional) for an R/D&I system which is established and mature.

4. Further, different policies/strategies/mechanisms may be needed when the R/D&I institutions and/or functions are at different stages of development than when their levels of development are "in balance".

We need, however, to understand that the concrete meaning of "maturation" may differ significantly across sectors. Thus, for example, even at a "mature" stage of development we would not expect to find the same level of clarity and certainty in the evaluation research function in a social science sector such as education as we would in a physical science sector. The realization of inherent differences between sectors will be important if we are to avoid making incorrect comparisons of (and developing the wrong expectations for) one R/D&I system in relation to other R/D&I systems.

2. A Framework for "Mid-Level" Analysis

Our comparative analytical framework serves to focus attention on a somewhat neglected area of research and analysis, sometimes referred to as "mid-level" or "mid-range". As used here, this "mid-level" refers to research and analysis which is somewhere between the broad level of general theory and the narrow level of specific cases.

At the general theory level, the purpose of research and analysis is to develop concepts and relationships which serve to describe all situations (i.e., theories). The approach at this level is to develop processes of research and analysis which will uncover the broadly generalizable concepts and relationships. While important, general level theory lacks the specificity which is needed by policy and decision makers.

At the specific case level, the purpose of research and analysis is to discover and demonstrate the uniqueness of each situation, and the approach to research and analysis is designed specifically to uncover such uniqueness. At this level, research and analysis tends to lack bases for generalizability. Thus, this level of research and analysis also has limited value for policy and decision makers.

Our comparative analytical framework utilizes a disciplined configurative approach that will permit systematic comparison of various sectors or policy/strategy issues. The purpose is to develop appropriate areas of generalizability which allow one to take into account the uniqueness of specific situations.

3. Describing R/D&I Systems in Terms of Their Interactive Features

In developing a theoretical framework, we have identified nineteen key R/D&I system features which we believe will be helpful both to the researcher and to the decision maker (see Figure 1). For simplicity of presentation, we have grouped these nineteen features into the following categorical framework (using a general systems theory approach):

1. The R/D&I System's Environment

   This category will include those features which are external to the R/D&I system itself, but which may nonetheless impinge upon and affect the system -- and, alternatively, which the R/D&I system may affect (e.g.: social, legal, political, economic, technological environments).

2. Operative System Conditions

   This category will include features internal to the R/D&I system which affect the way the system operates but which are not activities by which the system creates or utilizes knowledge. These features will thus include general system conditions (e.g.: historical development), aspects of system management (e.g.: administrative processes) and system inputs and outputs (e.g.: personnel base).

Typical Comparative Features

I. ENVIRONMENT	1. Environments of the R/D&I System
II. OPERATIVE SYSTEM CONDITIONS	
SYSTEM	2. Historical Development
	3. Institutional Base (Network of Institutions)
SYSTEM MANAGEMENT	4. Goals, Policies, Strategies
	5. Administrative Processes
SYSTEM INPUTS AND OUTPUTS	6. Personnel Base
	7. Funding
	8. Information Flow
	9. Innovations
III. R/D&I FUNCTIONS	10. Need Identification
	11. Generation/Research
	12. Development
	13. Production
	14. Marketing/Distribution/Dissemination/Diffusion
	15. Acquisition
	16. Implementation and Utilization
	17. Support Services
	18. Evaluation Research
IV. R/D&I RESEARCH	19. Research on R/D&I

Figure 1

Comparative R/D&I System Features

3. R/D&I Functions

This category will include those features which we would consider to be an integral part of a knowledge production to knowledge utilization process continuum -- i.e., what the system does to create and utilize knowledge.

Additionally, we have included an overview feature: Research on R/D&I. This will include any kind of research done about any aspect of the system (any of the features or feature issues; any element of the system such as a particular institution or set of institutions; etc.). The results of such research, in effect, provide the data base for analysis of the other features.

Within each feature, a number of relevant issues may be identified. An expanded discussion of these nineteen key R/D&I features and illustrative issues associated with each feature is provided in Chapter Two.

A different listing or arrangement of features and issues could, of course, be developed -- as we noted earlier. What is important is to recognize, identify and analyze the potiential or actual effects these various features may have (separately and/or in inter-action) on the total R/D&I system.

4. The Context of an R/D&I System

Taken together, the totality of the R/D&I system features and issues forms an interactive context in which analysis and decision making must be performed. The way an R/D&I system has developed over time in its sectoral environment; the types of institutions that have emerged; the character of the work and technologies; the personnel involved in each of the functions and institutions; etc. -- all contribute interactively to the totality of an R/D&I system's context.

For example, how an R/D&I system is structured will be influenced by such factors as the social, political and economic environments of the institutions that constitute the R/D&I system; by the degree of system institutionalization; by the nature of the work to be performed; by the history and state of the system's development; by the nature of the system's personnel base; etc. But in turn, these same variables will also be influenced by the structure of the R/D&I system. Such is the interactive nature of the R/D&I system context -- each R/D&I system feature acts both as an independent variable (as part of the total system context, affecting the other parts of the system) and as a dependent variable (which may be a focal concern for analysis and decision making).

In any given instance, analysis or decision making will, of course, be focused on some subset of contextual features or issues (or even on a single feature or a single issue of a feature). Such a narrowing of focus is necessary to bring the analytical/decision processes down to manageable and meaningful levels. Indeed, it is important to recognize that each feature has important characteristics which do distinguish one feature from another -- differential characteristics which often have important implications for both analysis and decision making.

However, the consideration of any single feature (or issue) must take into account the interaction of that specific feature with all other features -- i.e., one must consider a single feature or issue within the richness of its total context. To try to analyze any single feature (or issue) without considering its contextual interaction would not only be inadequate -- it would likely be quite dysfunctional, leading to wrong conclusions by the analyst and to wrong decisions by the decision maker. Such is the interdependence within an interactive living system.

Therefore a context has to be understood as the intersection of the effects or influences of each of the system features. If we wish to understand the character and managerial requirements of a given feature or issue (e.g.: the personnel base) it will be necessary to view this feature against the back-

ground of all other elements or features of the system in its context. By the same token, if we are concerned with a sub-issue within the personnel base feature (e.g.: the flow rate of certain types of personnel in and out of the system), then we would also have to include all the other aspects of the personnel base feature (e.g.: the types and levels of professionalism) as part of the relevant context for that sub-issue.

5. A Framework for a Comparative Sectoral Analysis of R/D&I Systems

In order to identify and differentiate between generic and sector-specific characterstics of R/D&I systems, it is necessary to do a cross-sectoral comparative analysis of R/D&I systems within their various specific sectoral contexts. This we will do illustratively in the later chapters of this report. The literature on R/D&I and the extensive research experience of our research group at CISST and Northwestern University relevant to R/D&I will provide the basic data for this comparative sectoral analysis.

However, we must first provide a framework within which to do such a cross-sectoral comparative analysis. We have already discussed the basic elements of this framework: features and issues, context and sectors. It is now the task to describe how these elements can be brought together to form a comparative analytical framework. This we will do in a step-by-step fashion, and we will distinguish between the comparative analytical frameworks useful for researchers and those for decision makers.

A. A Focused Process of Analysis

To attempt to analyze simultaneously all R/D&I system features, characteristics, issues, etc. would be impossibly voluminous and complex -- even within a single sector. Similarly, it would be impractical to attempt an analysis of even a single feature across all possible sectors. Out of sheer necessity, it is necessary to narrow the focus of analysis. This may be done by focusing on a specific R/D&I system feature or issue across a selected set of sectors. This narrowing of focus will enable us to identify the important characteristics of an R/D&I system feature or issue.

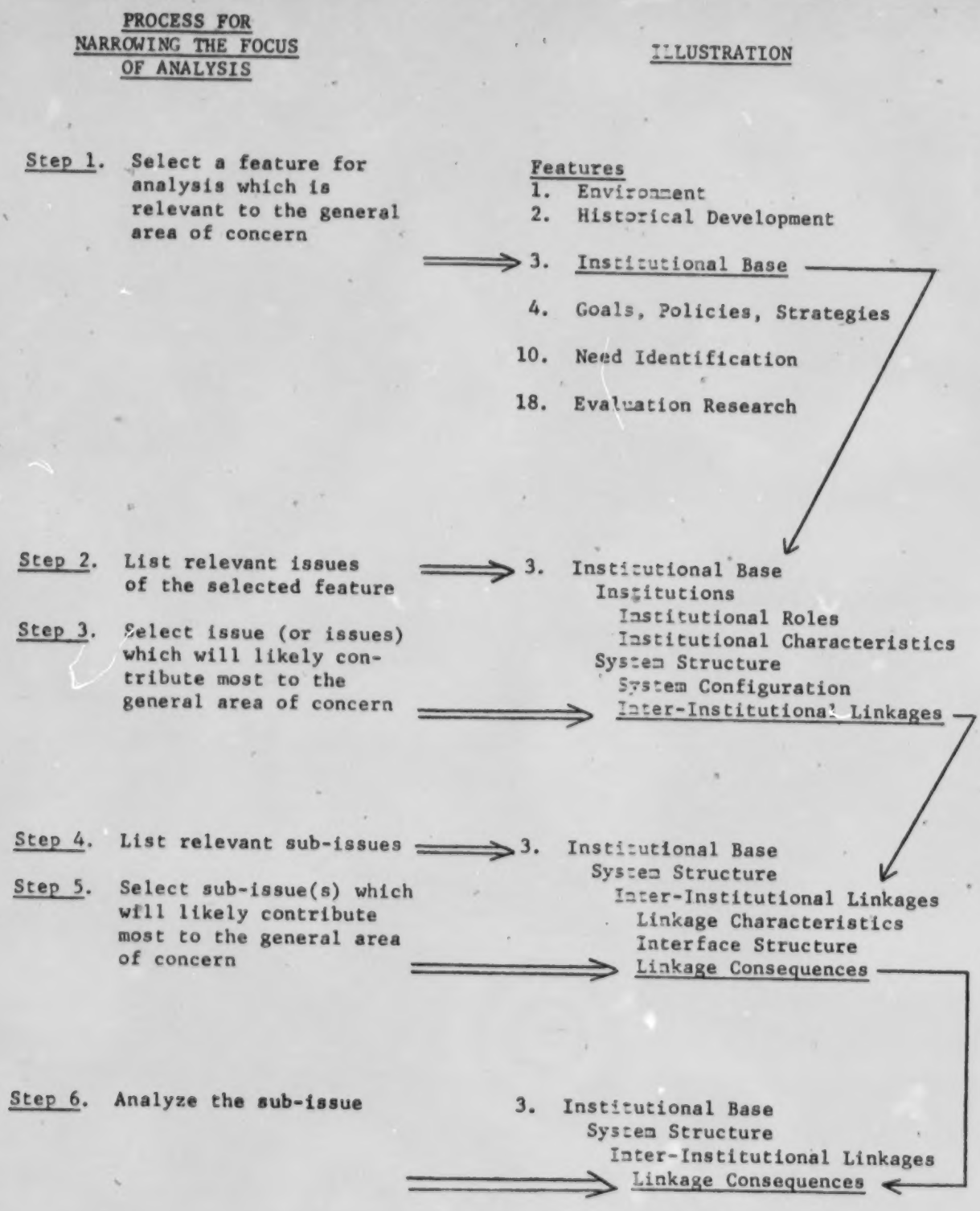
PROCESS FOR NARROWING THE FOCUS OF ANALYSIS
ILLUSTRATION
Step 1. Select a feature for analysis which is relevant to the general area of concern
Features
1. Environment
2. Historical Development
3. Institutional Base
4. Goals, Policies, Strategies
10. Need Identification
18. Evaluation Research
Step 2. List relevant issues of the selected feature
Step 3. Select issue (or issues) which will likely contribute most to the general area of concern
3. Institutional Base
Institutions
Institutional Roles
Institutional Characteristics
System Structure
System Configuration
Inter-Institutional Linkages
Step 4. List relevant sub-issues
Step 5. Select sub-issue(s) which will likely contribute most to the general area of concern
3. Institutional Base
System Structure
Inter-Institutional Linkages
Linkage Characteristics
Interface Structure
Linkage Consequences
Step 6. Analyze the sub-issue
3. Institutional Base
System Structure
Inter-Institutional Linkages
Linkage Consequences

Figure 2

An Example of the Process for Narrowing the Focus of Analysis

Figure 2 illustrates how the focus of analysis may be narrowed in successive steps until a level of analysis is reached where the analysis is sufficiently narrowed to be feasible yet still robust enough to permit meaningful analysis. Thus, the process narrowing the focus of analysis improves the "resolution" of what initially is likely to be a somewhat vague, "blurry" picture of a general area of concern about R/D&I systems. Of course, how broad or narrow the focus of analysis should be depends upon the purpose of the analysis.

B. A Cumulative Process of Analysis

Obviously, the analysis of a single feature or issue would not give us a full picture of R/D&I systems. Thus, separate analyses must be made of a range of features and issues -- analyses which though done separately would cumulatively provide a fuller picture of R/D&I systems. Cumulatively, these separate analyses will enable us to identify similarities and differences (a) among the features and (b) across sectors. Which and how many features and issues (and in how many sectors) are to be so analyzed will be determined by such factors as: time limitations; availability of data; the interest of the researcher, analyst, or the decision maker; or the specific purposes for which an analysis is needed. Of course, the ideal would be cumulative analyses of all possible features and issues across all possible sectors -- but as this is unrealistic (and probably not necessary), selections must be made.

C. Interactive Analysis by Context

Having chosen a feature or issue to analyse comparatively across sectors, it is necessary that the analysis be done as a contextual analysis. That is to say, while any given feature may have its own particular characteristics, the feature is a part of an interactive system. Each feature affects and is affected by all the other fea-

tures (i.e., context) of an interactive R/D&I system -- and no single feature can be adequately understood apart from its interaction with the other system features.

The interaction involved in a contextual analysis has a very important role. In essence, it keeps the analysis of a selected feature or issue in proper perspective relative to the overall picture of the R/D&I system. It guards against the danger that the feature or issue being analyzed (which is only a part of the total R/D&I picture) might be treated as if it were isolated and independent.

D. Delineation of Generic and Sectoral Characteristics

When a feature or issue is contextually analyzed across several sectors, it will become possible to identify similarities (i.e., generic characteristics) and differences (i.e., sectoral characteristics) of the feature or issue across sectors. While this identification of generic and sectoral characteristics must be considered tentative at this point in time, at least there will be findings which can be subjected to a more scrutinizing analysis and empirical verification.

E. An Iterative Process

We must note at this point that the comparative analytical framework we have just described is an iterative -- not a unidirectional -- process. While the initial flow of the process is from sectoral contextual examination to identification of generic and sectoral characteristics, reversing the process is also important. That is, the generic and sectoral characteristics that are identified should provide a fresh perspective from which to examine the sectoral context.

This helps to satisfy the point made earlier by Kelly and Kransberg[1] that we have "...an immediate need for an iterative interactive relationship between theoretical and emperical research".

F. Summary

Figure 3 summarizes the above discussion of the comparative analytical framework.

6. Agency Use of the Comparative Analytical Framework

Thus far, we have described a comparative analytical framework for identifying generic and sectoral R/D&I system characteristics. While this is sufficient for research purposes, we need to take the process one step further in order that the comparative analytical framework be useful for the decision maker -- that is, using the framework to identify and evaluate policy and strategy options. To do this, we simply modify the sectoral, analytical framework (described in Figure 3).

Figure 4 describes the analytical framework which would be useful for decision makers. As figure 4 indicates, this analytical framework remains:

1. a focused, cumulative process of analysis (though now the focal point of analysis may also include policies and strategies -- a useful addition for the decision maker);
2. an interactive analysis by context; and
3. an iterative process of analysis.

However, we no longer focus on a cross-sectoral comparative analysis per se (though of course we do use the available cross-sectoral comparative data as relevant).

Instead, we now focus upon an iterative analysis of:

1. generic R/D&I system characteristics (which have been identified through the cross-sectoral process of comparative analysis);
2. sectoral contextual characteristics of the specific sector involved (e.g.: education; health); and
3. sub-sectoral contextual characteristics (as relevant; e.g.: the drug field within the health sector).

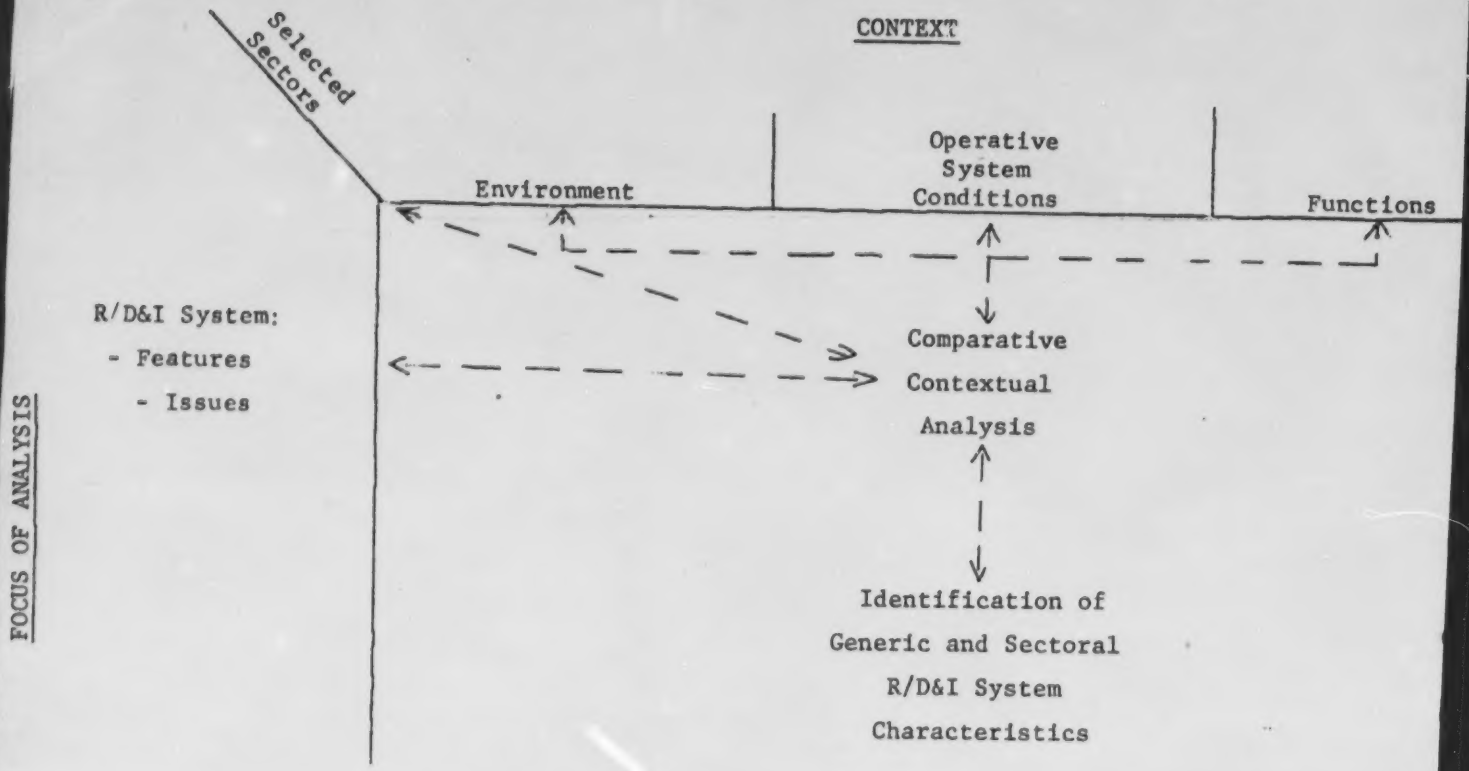

Figure 3

Framework for Comparative Sectoral Analysis of R/D&I Systems

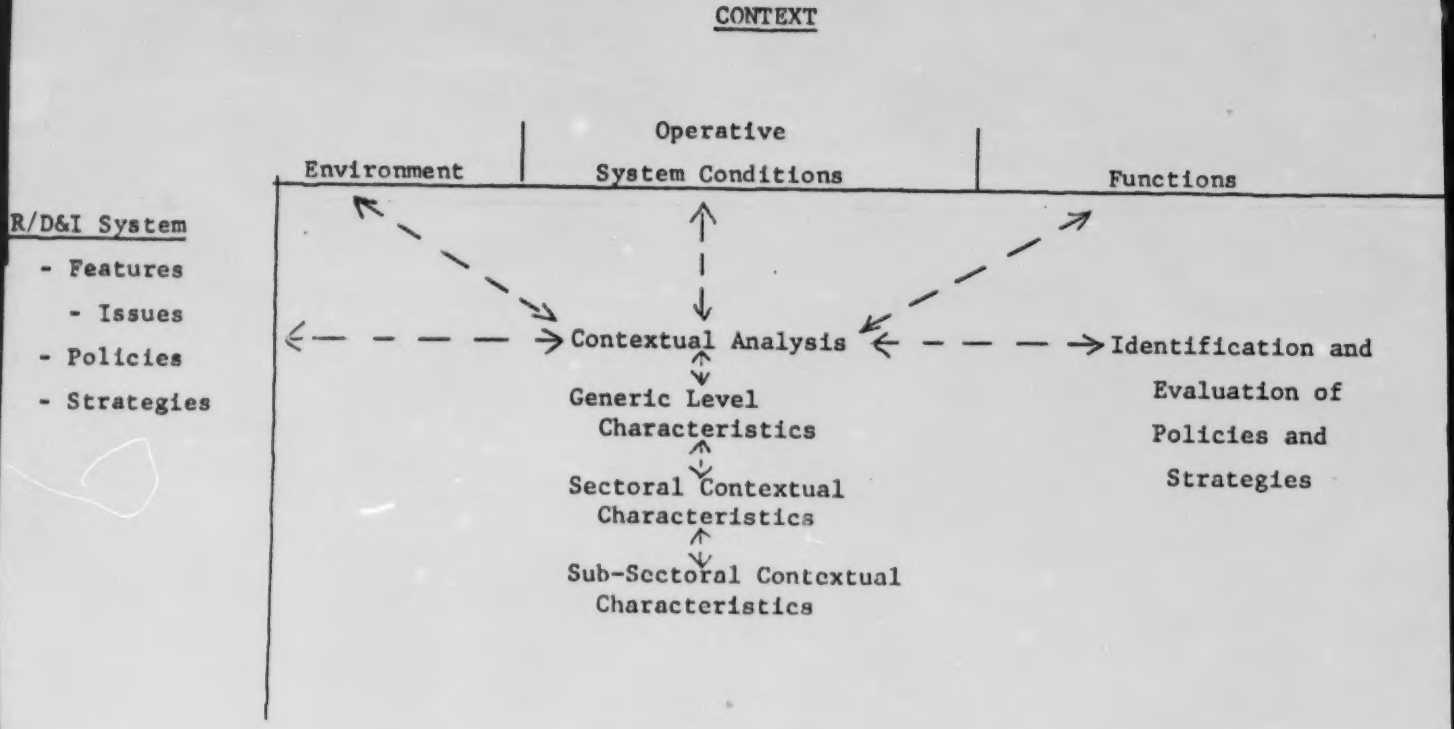

Figure 4

Analytical Framework for Policy Makers:
Identification and Evaluation of Policies and Strategies

In essence, the framework we are now describing is an iterative contextual analysis of one or more selected R/D&I system features, issues, policies or strategies in light of what is known about relevant generic R/D&I characteristics and about the characteristics of the given sector (and, as relevant, of the given sub-sector).

This framework will permit us to compare descriptive findings of system features and issues (the sectoral context) with what we would expect (or would want) to find from the generic perspective. For example, if funding stability and its consequences for basic research is a generic issue for all R/D&I systems, it would be possible to examine the sectoral context in terms of potential for funding stability and to observe whether the outcomes for varying conditions did or did not meet expectation.

Management and policy options could then be generated and action taken that would either deal with the nature of the funding stability or with the procedures being used to cope with the given level of stability. The process is dynamic in that the policy and management actions taken themselves become part of the context-forming process in a feedback mode.

7. Deductive or Inductive Analysis

We should note again at this point that the framework of analysis we have described may be used either deductively or inductively. That is, generic questions can be used as guides or maps to explore real-world conditions (deductive). Alternatively, observations or reports of real-world issues and problems can be traced back to their generic roots (inductive). In either case, the objective for the decision maker is to identify policy options relevant to the observed issues, take any necessary actions, and evaluate the outcome. Thus:

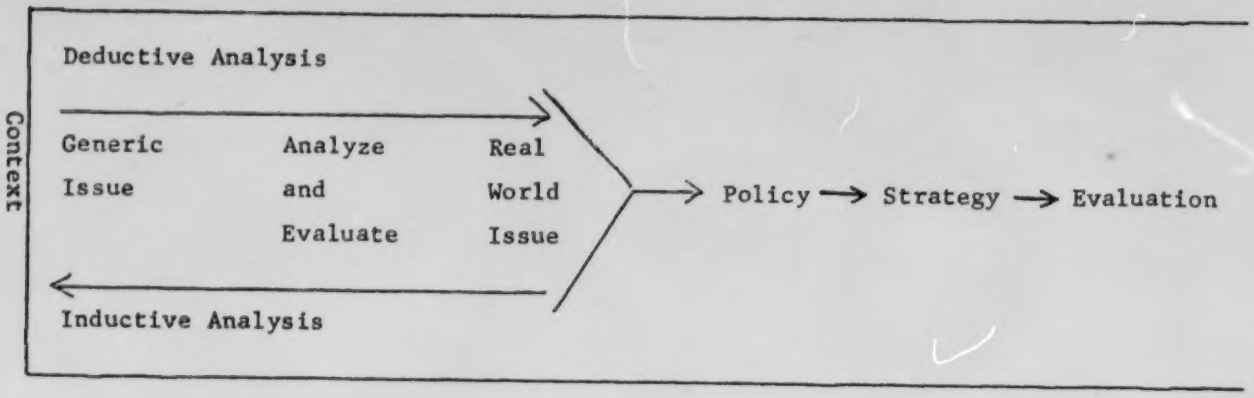

Figure 5

A Deductive/Inductive Framework

V. Conclusion

In this chapter, we have attempted to provide a general understanding of the nature and utilization of a contextual approach to the comparative analysis of R/D&I systems. To further develop an understanding of contextual analysis, we will in Chapter Two expand our discussion of the R/D&I features which (together and interactively) provide the total context in which R/D&I must be understood.

Chapters Three through Six will illustrate how specific sectors may be described and analyzed contextually. Chapter Seven will illustrate how these sectors may be analyzed comparatively.

Chapters Eight, Nine and Ten will then illustrate how the contextual analytic approach may be utilized to lead one into a detailed focused analysis of key R/D&I issues relative to a specific R/D&I feature. Chapter Eleven will briefly review how we have used the contextual analysis framework in the analysis of a variety of policy issues in three sectors.

In the final chapter (Chapter Twelve) we will "look back" across the first eight chapters in terms of understanding how the use of contextual analysis may benefit the R/D&I researcher (and policy analyst). We will then briefly "look ahead" in terms of what we see as "next steps" in the development and use of our contextual analysis framework.

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CHAPTER TWO

DISCUSSION OF THE R/D&I CONTEXTUAL FEATURES

Major contributions to this chapter were provided by William Hetzner and Earl C. Young.

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PART ONE

ENVIRONMENTS

I. ENVIRONMENTS

Every system exists within and interacts to varying degrees with an environment. The importance of the relationship between system and environment has been indicated by a growing body of research and theory, based explicitly or implicitly on open system models (c.f. Duncan 1972, Emery and Trist 1965, Lawrence and Lorsch 1967, and Thompson 1967). This research indicates that 1)the interaction processes between a system and its environment influence system behavior in predictable ways based on 2)the nature of interaction (i.e., turbulent or tranquil) between components of the environment (Burns and Stalker 1961; Duncan; Emery and Trist; Lawrence and Lorsch; Woodward 1965).

The dominant theme of early studies on the interrelationship between system and environment is that environmental factors control system organization and behavior: that certain patterns of organization and behavior are more appropriate for certain environmental (and task) characteristics (c.f. Burns and Stalker Lawrence and Lorsch, and Woodward). System environment interaction in these cases is initiated and "controlled" by the environment. These studies, however, deal only with contemporary industrial organizations in the U.S. and Europe.* Work by Emery and Trist;

*This is a characteristic not only of open systems theory, but also much of the literature on R/D&I and innovation. Rogers (1962) and Havelock, et al (1971) in reviewing the "diffusion" literature indicate three major schools or traditions of research namely Rural Sociology, Education and Industrial Research. Of these schools Rural Sociology has the greatest history of research, mostly concerned with the innovation of individual farmers. Education has primarily concerned itself with the characteristics of innovative school systems. Emerging from the industrial research tradition in recent years have been approaches involving many disciplines (e.g., economics, organization theory and behavior, industrial psychology. etc.) and perspectives, which deal with all or major portions of the innovation process, utilize a variety of units of analysis (i.e., the technology, the adopting unit, the source) and focus on a variety of systems (government, health care, industry, etc.)

Duncan; and Terreberry (1968) suggest that interaction dominated by the environment may be relevant to "turbulent" environments which can be characterized as composed of many highly interconnected components, with an accelerating rate of change within and among components. For "less" turbulent environments other patterns of interaction have been shown to exist. We must, therefore, consider processes in the environment itself to determine what Emery and Trist have called its "causal texture."

The concept of environment herein is quite general. Environment includes everything (groups, organizations, tasks) that may be considered external to the R/D&I system. We are not primarily concerned with the issue of what is part of the system's environment and what is part of the system (i.e., the boundary question). As we indicated earlier, definition of the system's boundary depends upon the purposes of discussion or analysis. The central issue is the nature and effect of actual or potential interactions between various parts of the R/D&I system and relevant sub-environments.

The various sub-environments of the R/D&I system can be described or classified in many ways. The following is one such classification scheme which has at least a general level of common usage. Specific questions are directed at an understanding both of the effects of specific sub-environments on the R/D&I system and, conversely, of the effects of the R/D&I system on these sub-environments. Causal texture is addressed by considering the number, types and location of groups, organizations, tasks, or other components which make up a sub-environment and the interrelationships among these components and among sub-environments. It should be noted that while the issue questions listed below generally refer to the R/D&I system or sector, they may also apply to institutions within the R/D&I system.

A. Political/Legal Environment

Government institutions, laws, regulations and policies can constitute a significant portion of the R/D&I system's environment and can greatly impact system organization and behavior. While one can expect the impact of government to be greatest in planned economies, government can and does have both a direct and indirect impact on R/D&I systems within free enterprise economics. In the United States, for example, the federal government has become increasingly active in carrying out and supporting R/D&I primarily related to national security (i.e., defense) but also in sectors considered to be in the national interest, which the private sector has been unable or unwilling to adequately support (e.g.: agriculture, education, energy, environment, fire, health, law enforcement, transportation and many "basic" research activities). For R&D alone, government support has increased from less than twenty percent of total R&D expenditures in 1930 (Mansfield 1968) to over fifty percent in 1973 (Science Indicators 1974).

Government policies, laws and regulations have the effect either directly (e.g.: patent laws) or indirectly (e.g.: anti-trust policies) of regulating, controlling and guiding all or significant aspects of R/D&I processes (c.f. Averch and Johnson 1972, Capron 1971, Gellman Research Associates 1974, Hamberg 1966 and Kelly and Kranzberg 1973). While most of the studies of the effects of government/political institutions and activities on R/D&I such as those cited above have concentrated on industrial innovations in developed Western economics, this research may have implications for other systems, sectors and economies (which can include aspects of industrial innovation processes).

Keeping in mind the general discussion of the system and environment relationship, the following kinds of questions dealing with

identifying legal/political environment components and the nature of the relationship between environmental components and the R/D&I system* emerge:

What are the legal processes which affect or potentially affect the R/D&I system or sector? Are they many or few? Similar or dissimilar? Stable or dynamic?

What are the short and long term consequences of these processes on R/D&I systems or sectors?

In what ways and with what effects does the R/D&I system or sector influence or seek to influence legal processes?

What are the institutions (and who are the key individuals) involved in these legal processes? Are they many or few? Centralized or diffuse?

Are the relationships among and within legal institutions and processes stable or dynamic?

What are the existing and potential governmental policies and regulations regarding innovations relevant to the R/D&I system or sector? Are they many or few? Similar or dissimilar? Stable or dynamic?

What are the consequences of these policies and regulations on the R/D&I system or sector?

In what ways and with what effects does the R/D&I system or sector

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*Issues dealing with the interaction among sub-environments are discussed in Section E.

influence or seek to influence policy making and regulatory processes?

Who are the institutions (and key individuals) involved in relevant policy making and regulatory processes? Are they many or few? Centralized or diffuse?

Are the relationships among and within policy making and regulatory institutions stable or dynamic?

B. Social/Cultural Environments

The concept of social and cultural environment is all pervasive. Societal values, motivations and behaviors provide not only the cultural conditions for the development of R/D&I systems and sectors, but also are major determinants of the characteristics of other environments (e.g.: economic, legal/political) needed to support this development (Merton 1973, and Kuhn 1962). That R/D&I systems and sectors have developed in societies of a certain type and not in others, based on self-evident cultural values (e.g.: of "scientific truth"), does not require explanation. More importantly, the systems of values and institutional structures within societies influence the rate and direction of this development. Systems of values - - economic, political, cultural, humanitarian, nationalistic, religious - - vary within and across regions, countries and even groups of countries. These differences in values are important in that they give prestige to different R/D&I disciplines and foster the development of differing types of R/D&I and supporting institutions (Merton). Furthermore, changes in values (e.g.: toward "utility" in science) can serve to shift career choices among R/D&I personnel and change the character of institutions.

The relationship between R/D&I systems and their social/cultural environment is by no means unidirectional. R/D&I innovations, for example, can affect societal changes (Rogers and Shoemaker 1971). Kelly and Kranzberg (1975) use the examples of the automobile and television to indicate major societal changes brought on by the

adoption of innovation. R/D&I systems can also resist social change through such means as the development of innovations that support traditional values and institutions. Kelly and Kranzberg use the example of innovations related to the production and distribution of energy as maintaining the values and institutions of automobile transportation. Other more subtle means of influencing the larger society include participation by R/D&I personnel in governmental, political, religious and humanitarian groups.

From the above discussion it is clear that the concept of social/cultural environment is complex. It may be local, regional, national, international in nature or include some combination of these levels. Different R/D&I subsystems may have different social/cultural environments according to their geographical location or the R/D&I function involved. Different sectors or different types of innovations may be differently impacted by the social/cultural environment. There may be differences in the rate of socio/cultural change among environments.

Due to the complexity and pervasiveness of social/cultural environments (as well as a lack of systematic, empirical research) (Kelly and Kranzberg), issues to be addressed in this section tend to be at a fairly general level, but are nonetheless important. These issues could include:

What social/cultural norms and values influence knowledge production and knowledge utilization in the R/D&I system or sector? In what ways and with what effects?

How is R/D&I perceived by the relevant society or culture in terms of status, legitimacy, and support?

Is the society or culture open and responsive to innovation and change? What kinds?

How does the R/D&I system act to influence the rate and direction of change in the society (i.e., overcome barriers, or guide the direction)?

What are the actual or potential socio-cultural sources of political pressures on the R/D&I system? Are they many or few? Centralized or diffuse? Are relationships among these sources stable or dynamic?

What are the actual or potential consequences of these pressures on the R/D&I system?

How does the R/D&I system respond to, influence or confront these pressures (versus accept)?

What alternative career opportunities (within and outside the system or sector) are available to R/D&I personnel?

What R/D&I career opportunities are available to personnel from outside the system or sector?

What relative status do alternative careers (in and out of R/D&I) have?

C. Economic Environment

The primary characteristics of an R/D&I system or sector's economic environment are the level, stability (or rate of change) and availability of capital resources. R/D&I can often be quite costly and obtaining adequate capital to carry out all or significant aspects of the R/D&I processes is critical to the success of these processes (Hamberg 1966, Kelly and Kranzberg 1975, Mansfield 1968, Rubenstein 1964).

To obtain adequate capital resources, R/D&I systems must compete in terms of expected costs and benefits with other investment possibilities (e.g.: capital improvements, human resource development programs) in internal investment decisions and in going outside the system for investment capital. The costs and benefits of R/D&I, however, are often difficult to determine with any degree of accuracy due to the often considerable time lags between investment and payoff and the uncertainties of R/D&I processes. These uncertainties are also affected by the nature of the R/D&I system, in that they are greater for the "soft" (i.e., social and behavioral) than for the "hard" sciences.

While time lags and uncertainties do vary for different phases of innovation processes and for different types of innovations, R/D&I does seem, in general, to be more directly affected by general economic conditions than other more predictable and timely investment opportunities (i.e., replication of existing activities)(Charpie 1967). On the other hand, it is also evident R/D&I has had and will continue to have a significant positive impact on economic conditions. Clearly, one need only look at developed and less developed countries to show that innovation does contribute at some point in time to economic development. Attempts, however, to link innovation in its broadest context (i.e., social and technological) to economic growth have varied greatly in their results (i.e., from 2 to 87% of GNP) (Denison 1969, Jorgensen and Griliches 1967, Mansfield 1972, Solow 1957). Even in times of general economic prosperity and sustained growth, capital does not necessarily flow "naturally" into R/D&I activities. Rather, funding for R/D&I generally comes from outside the R/D&I system or sector (Kelly and Kranzberg 1975). The set of issues involved in funding is of sufficient importance, however, that it will be dealt with separately in Section VII. Some illustrative issues dealing with more general economic conditions are as follows:

What is the state of the host economy (of a country) in general and for the sector served by the R/D&I system in particular?

What is the development pattern of the host economy (i.e., rich or poor nation; industrial/non-industrial; mixed or narrow based economy; lesser developed country or developed country)?

What is the level of priority given to R/D&I in the public and private sectors of the economy and within the particular sector served by the R/D&I system? Do the levels of priority vary among the R/D&I functions? If so, with what effect on R/D&I?

What is the overall level of expenditures in the sector served by the R/D&I system?

To what extent is the R/D&I system vulnerable to short term and/or long term fluctuations in the general or sectoral economy? What preparations or responses does the R/D&I system make in relation to economic fluctuations?

D. Knowledge/Technology Environment

While it is obvious that an R/D&I system and its institutions are dependent upon available knowledge/technology, the linking processes between knowledge/technology and innovation are not at all obvious and, indeed, have been the subject of much debate. In the last twenty years, for example, it has become common to link the problems of national development in developing countries with the development of an indigenous science capability (Shills 1968). With the development of a science capability, however, national development has not "naturally" resulted, at least not to a level considered acceptable to national policy makers.

Applying available science has now become the emphasis of national development in many developing countries. In attempting to apply science, developing countries are to a great extent relying again on the experience of Western nations, which are just beginning now to understand the complexity of the linkages between knowledge/technology and innovation (Cooper 1973, Stewart 1977). However, it is also becoming clear that a straightforward unqualified application of the experience of Western advanced nations to the context of the developing countries can itself lead to adverse consequences. The context specificity of scientific and technological application, and thence of R/D&I systems is an important issue in development. The whole question of "appropriate" technology emerges from this issue.

Utilizing historical analyses, various studies have shown both that an R/D&I system generates much of its own technology (Price and Bass 1969, and Isenson 1967), and that R/D&I is heavily dependent on its knowledge/technology environment (Battelle 1973, IIT Research Institute 1968, and Myers and Marquis 1969). In an attempt to resolve these apparently conflicting empirical findings, Gibbons and Johnson (1973) analyzed information sources and information content in the development of innovations and the resolution of technical problems in industry and found that "the relationship between science and industrial technology is more complex than previously assumed by either scientists or economists; there exists a variety of potential forms of interaction" (pp. 34-35). Therefore, while knowledge/technology does contribute both directly and indirectly to innovation, the complexity of this relationship effectively precludes universal policies, practices and procedures for facilitating innovation.

Some important issues in analyzing the knowledge/technology environment include the following:

What is the level of sophistication (state of development) of the knowledge/technology base?

What kinds of knowledge/technology are or are not available?

What factors and processes affect the development, acquisition and use of the knowledge/technology base?

What are the basic disciplines and/or sectors from which the R/D&I system draws its knowledge/technology? What are the mechanisms, barriers, etc., for transfer of knowledge/technology between disciplines, R/D&I sectors, R/D&I systems, R/D&I institutions?

What technologies are generalizable (transferable) across sectors and which are not? Why not? Across which sectors?

What is the state of development of the R/D&I system? How does this affect the R/D&I system's capability to identify, select and use potentially relevant knowledge/technology from other R/D&I systems?

What are the comparative states of development of the knowledge/technology base among the different R/D&I functions? What effect does this have on the overall knowledge production/knowledge utilization flow of innovation (e.g.: if the knowledge/technology of development is significantly more sophisticated than the knowledge/technology base relevant to implementation/utilization)?

How feasible is technological forecasting? To what extent is it done (and how) by the R/D&I system and its institutions?

E. The Causal Texture

To gain an understanding of the causal texture of the R/D&I sys-

tem's environment, we must also address issues relevant to the existing and potential relationships among sub-environments. Each sub-environment has not only direct effects on R/D&I systems or sectors, it is also interactive with other sub-environments. Considering knowledge/technology for example, the value placed on knowledge/technology in general and specific areas or disciplines in particular is manifested in public policies, the level and direction of investments in knowledge/technology and in the membership of the knowledge/technology community (Kelly and Kranzberg 1975).

Potential issues related to the interaction among sub-environments include:

Are the gaps or underdeveloped areas in knowledge/technology or basic disciplines/sectors from which the R/D&I system draws its knowledge/technology likely to be filled in the foreseeable future (e.g.: is government, universities or the private sector attempting to develop the knowledge/technology base in these areas)? If not, why not? Have the areas been simply overlooked or do they represent a lack of societal concern?

How can and does the R/D&I system act to influence the development of relevant knowledge/technology areas?

What are the relationships between sources of political pressures and legal, regulatory and policy making institutions? Are they many or few? Centralized or diffuse? Stable or dynamic?

What are the potential (or historical) consequences of such pressures on governmental policies, regulations and laws?

What are, have been or might be the responses of the R/D&I system or sector to these pressures?

To what extent do economic conditions affect legal/political

processes (e.g.: are regulations and laws more strictly enforced during times of prosperity?)?

To what extent do legal/political processes affect economic conditions for the R/D&I system or sector?

To what extent is available scientific and technological knowledge or expertise utilized in legal, regulatory and policy making processes?

If scientific and technological knowledge and expertise are utilized, is it frequent or sporadic? Is the knowledge or expertise broad-based or narrow? Are regulations, laws and policies reviewed and updated in light of new knowledge or expertise? Under what conditions is it used or not used?

F. Other Environments

There are other environments which may be of importance to particular R/D&I systems or sectors that have not been covered in this section. Industrial R/D&I, for example, must concern itself with the material and energy resource environment. Issues relevant to these other environments would follow the general areas covered above, namely the exchanges between R/D&I and its sub-environment and between the sub-environment and other sub-environments.

G. Summary: Environmental Influences

The issues posed herein are directed at an understanding of the interactions between the R/D&I system and its environment, and among elements in the environment. For specific systems or sectors, our ability to address these issues will vary greatly. For some systems, the issues may be quite straightforward, for others they may be unanswerable. But even if the issues are not totally answerable,

we have gained valuable information about the system/environment interface. As Duncan (1972) and Lawrence and Lorsch (1967) contend, the turbulence of a system's environment is indicated in part by uncertainty of information concerning causal relations in the environment.

Uncertainty of information has possible implications for system organization and behavior. Lawrence and Lorsch found that diverse or turbulent environments required higher states of differentiation or differences in subgroups in terms of their attitudinal and cognitive orientation and integration or the state of collaboration existing among subgroups (as perceived by members of those subgroups) than more stable environments. Greater differentiation was needed to deal with the diversity of environmental demands, with a high level of integration required to bring together these differentiated units. Integration was accomplished through integrative roles, cross functional teams, and integrative departments, as well as through a more open and confronting mode of conflict-resolving behavior.

The work of Lawrence and Lorsch and others (Duncan, Burns and Stalker 1961, and Woodward 1965), therefore, indicates both the importance of explicity addressing environmental issues, and that there is valuable information to be gained even if the issues are not completely resolvable.

PART TWO

SYSTEM

II. HISTORICAL DEVELOPMENT

Knowing and understanding the past history of an R/D&I system is an important feature of the contextual analytic framework in that it provides perspective on the present and future directions the system may take. The history of a system is reflected in its current organization and behavior, and more importantly, tends to constrain policy and decision making activities that shape the system's future (Katz and Kahn 1966, and March and Simon 1958). "Individuals and organizations," as March and Simon state, "give preferred treatment to alternatives that represent continuation of present programs over those representing change" (p. 173).

This preferred treatment to present programs is a result of the "social and organizational environment" of the policy/decision maker. Our analysis of historical development, therefore, must include not only the current level of development or maturation, but also the complex of sectorial and societal factors that have shaped the direction of this development (Schon 1971).

In general, available historical analyses are not sufficiently systematic for the purposes of contextual analysis because they rely on either conventional wisdom or are undertaken to confirm a particular view of history. As Merton (1973) argues, "what everybody knows turns out to be not so at all" (p. 183). In the following, some illustrative issues are posited that will help us to understand where an R/D&I system is at, how it got there, and where it appears to be going, can go or should go.

A. Development Phases

Institutions and systems do go through phases of development (c.f. Downs 1967, Himsworth 1970, Kuhn 1962 and Merton 1973). A simplification of what is a quite complex dynamic would be to say that

systems have introductory, transitional and mature phases of development. These phases could be characterized as follows:*

1) Introductory Phase - System linkage, coordination and overall management and direction are not well defined. There are significant gaps in the system. Knowledge/technology and institutional bases are underdeveloped. The attention given to various R/D&I functions is uneven and unbalanced. Issues and concerns are localized rather than at a system level.

2) Transition Phase- Institutional linkages, coordination, and overall management and direction become increasingly defined. Gaps in the system become evident over time. There are more established institutions and at least an identifiable knowledge/technology base. Members of the system begin to recognize certain issues and concerns as systemic rather than local, but the system is not yet capable of more than minimal self-orchestration.

3) Mature Phase - There are (where needed and appropriate) system linkages, coordination, overall management and direction, as well as developed, coherent knowledge/technology, institutional and personnel bases. There is a balance in the level of development of R/D&I functions (i.e., no significant "gaps"). The system is more capable of a significant amount of orchestration.**

The above simplified view of system development is descriptive and does not suggest that these phases are either normative or inevitable. Thus, we do not imply either that all R/D&I systems will inevitably

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*Abernathy (1975) used a similar phase model in analyzing product and process innovations in the automobile industry, indicating the usefulness of such a simplified model. Radnor et al. 1970 have also used a similar model for the implementation of OR/MS.

**The reader should recognize that this level of development is very tentative. Few R/D&I sectors or systems have, heretofore, reached such a level of development.

reach each stage or have "appropriate" forms of development (linkages, etc.); or that all potential characteristics of a phase will exist for every system; or that historical development is a one-way process. Indeed, if a "mature" system becomes static and out of touch with its environment, it may over time "decline" (and no longer possess the characteristics of a "mature" system) and/or repeat earlier phases of development.

In addition, the meaning of system maturation must be understood somewhat differently in different sectors and in different contexts. Thus, when compared (for example) with aerospace, even a "mature" R/D&I system in a social service sector such as education will always be somewhat more "messy in its knowledge base, system linkages, etc., simply because human/social systems have inherently highly value-laden contexts, have relatively hard-to-define goals and hard-to-measure outcomes, etc. And, additionally, industrial R/D&I systems may be more closely linked than social service R/D&I systems.

Thus, while the comments and issue questions which follow are of potentially critical importance, we must keep in mind that not all R/D&I systems are or need to be the same - - and that specific stage-of-development issues may apply differently to different R/D&I systems (Rogers et al 1976). With this in mind, some important issues about the development phase of the R/D&I system could be:

What is the level of development phase of the R/D&I system, the R/D&I functions, the R/D&I institutions?

Are the R/D&I functions within an R/D&I system at different levels of development?

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*The nature of what can be considered "appropriate" organizational/system forms will depend both on the level of international development and on the nature of the sectoral context.

Is the development level of an R/D&I system different from the development level of its sector?

Are the development levels of the R/D&I functions within a particular R/D&I system different from the development levels of the R/D&I functions in other R/D&I systems with which it does (or could) interact?

How do differences in levels of development impact the interaction between the R/D&I system and its sector, between R/D&I systems, between R/D&I functions within a single system? How do these differences affect the flow of innovation, the possibility of technology transfer, etc.?

To what extent is system-building a critical need of the R/D&I system? For what parts of the R/D&I system?

How well has a balance been maintained among the system's R/D&I functions in terms of proper sequencing within the overall system development process and in terms of most effective utilization of resources? Is there currently a need for staging/phasing policies and strategies in order to insure such a balance?

To what extent has some system-wide agency played a role in orchestrating the system, to fill "gaps", to balance the rate of development among R/D&I functions? Is there currently such a need?

Are system mechanisms established in the early stages of a system's development relevant to the current stage of the system's development? If not, what flexibility does the system have to modify (or even eliminate) these mechanisms?

What are the time/maturation effects on: system operation effectiveness; delineation of issues; establishment of priorities; institutionalization of the R/D&I system; acceptance of the R/D&I system and its outputs within the sector; etc.

B. Critical Events in the Development of the R/D&I System

Thus far, we have looked at historical development from a general broad-brush perspective. It is equally important to know about and understand the impact of the more specific historical events which have been critical in influencing the development of the specific nature or character of an R/D&I system. Such critical events may have impacted the R/D&I system in a variety of ways - - e.g.: influencing the major emphases or foci of the system; increasing or decreasing internal system capabilities; establishing patterns, precedents, priorities, requirements; supporting or blocking system activities or system development; influencing the relative rates of development of the system's R/D&I functions (and thus the "balance" among these functions).

Empirical studies of critical events in R/D&I have typically been limited to analyses of specific innovations, rather than R/D&I systems. Early studies (IIT Research Institute 1968, and Isenson 1967) dealt solely with scientific and technological events on particular innovations. More recently, Battelle (1973) included "nontechnical" events in its analysis of eight innovations. Non-technical events included such factors as the establishment of a cooperative research program for hybrid corn, the establishment of research funding agencies in the federal government for the video tape recorder and a Congressional request for a study of the economic effects of demobilization in 1941 for input/output economic analysis. Moreover, critical

scientific and technical events considered in the Battelle study were both organizational (i.e., development of an interdisciplinary team) and behavioral in nature.

The above studies, particularly the Battelle study, as well as trend analyses (c.f. Schmookler 1966) and historical analyses (c.f. Morison 1966) of innovations in industry, indicate the importance of critical events in R/D&I system development. From these analyses we can conclude that an examination of critical events includes not only developments in the scientific and technological state-of-the-arts, but also at least institutional (organizational), legal, political, and economic (funding) developments.

1. Institutions Established (or Disestablished)

When? Private or public? Profit or not-for-profit? Academic or non-academic? For which R/D&I system functions? How has the balance among the various types of institutions been affected?

2. Legal

What laws have significantly affected the development of the R/D&I system? In what ways? Why were these laws passed? At what level of government (federal, state, local)? In what ways have such laws changed over time, and with what effect?

3. Political

What specific events have significantly affected the R/D&I system over time? In what ways? What significant changes have there been in the political context? To the extent the political context has changed over time, what effect has the pattern of change had on the R/D&I system?

4. Development in the State-of-the-Arts

What has been the pattern of significant developments in the state-of-the-arts? Have the developments been relatively sudden or gradual? Major single developments or incremental developments? What effects have these developments had?

5. Funding

What has been the level of funding for the R/D&I system? Stability? What have been the major sources of funding? What have the significant events in funding been? What impact have these had on R/D&I?

Critical events in all of these areas may be seen as an "input" to the R/D&I system which have had some significant (though of course not exclusive) effect on determining the idiosyncratic nature and characteristics of the R/D&I system both as it currently exists and as it may exist in the future. We may also ask:

Have the critical events been "appropriate" to the state of the R/D&I system's development -- and if not, what has been the effect on the system?

III. INSTITUTIONAL BASE (NETWORK OF INSTITUTIONS)

An R/D&I system is generally composed of a variety of institutions which, loosely or coherently, form a network of institutions. Thus, we will want to examine the institutional base from two perspectives. First, we want to look at the institutions themselves in terms of their differentiation; what the institutional roles of the constituent institutions are within the R/D&I system; and their characteristics. Second, we will want to know how these institutions are integrated to form a "system"; what is the system configuration of R/D&I functions; how the institutions are linked together; what are the characteristics of the system structure (Langrish, et al 1972).

The perspectives of differentiation and integration with which we will view institutional bases have typically been applied to intra-institutional issues. Lawrence and Lorsch (1967), by considering the systemic properties of organizations, have extended these concepts such that they are relevant to inter-institutional issues.

Differentiation, Lawrence and Lorsch contend, is not only the segmentation of functions or tasks and specialization of knowledge, but also results in differences in goals, structures and styles of operation, resulting in differences in the cognitive and emotional orientation of members among segmented groups or organizations. These differences tend to create difficulties for integration or "the quality of the state of collaboration among departments that are required to achieve unity of effort by the demands of the environment" (p. 11).*

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*See Rubenstein et al (1969) and Doud (1970) for a discussion of differentiation/integration in R/D&I.

In terms of differentiation, therefore, we are concerned with determining at least the following characteristics (Forehand and Gilmer 1964, Lawrence and Lorsch, and Rubenstein et al. 1969).

1) number of constituent institutions

2) functional roles (division of labor) both on an intra-institutional and inter-institutional basis.

3) nature and specificity of goals*

4) structure as indicated by a) size, b) shape (i.e., degree of formalization of authority, rewards and skill, span of control, locus of formal authority, etc.)

5) style of operation as indicated by internal processes of decision making, communication, authority, cooperation, etc.

For integration we are concerned with the quality of collaboration among institutions in the R/D&I system as well as among R/D&I institutions and their corresponding environments, and the factors affecting the quality of collaboration (i.e., decision making processes, communication processes, authority/status relationships, linking mechanisms and conflict resolution) (Lawrence and Lorsch, Rubenstein et al 1969 and Schein 1968).

A. Constituent Institutions

An R/D&I system involves a variety of institutions which form the institutional base of the system. It will be important to identify these institutions. Here, some important issues could be:

*Considered in the section following (Section IV).

What institutions are involved in the R/D&I system?

Are they: public/private; profit/not-for-profit; federal/state/local government; universities/industries/professional associations; etc.

B Institutional Roles Within the R/D&I System

We will want to know what roles the various institutions have within the R/D&I system. Some important issues could be:

To what extent do the institutions specialize in particular R/D&I functions (e.g.: research, dissemination, etc.)? Which institutions? Which R/D&I functions (or combinations of R/D&I functions)?

What are the roles of the various institutions in relation to the R/D&I system as a whole, to other institutions of the R/D&I system, to other relevant institutions and systems in the environment of the R/D&I system (e.g.: what is the role of a government agency which is part of the overall R/D&I system)?

Do the institutions serve only (or primarily) the specific sector (e.g.: public schools, NIE, or the federally sponsored R&D labs in the education sector)? Or are they sector-spanning institutions which serve several sectors (e.g.: NSF, IBM, many R&D organizations, book publishers)? What is the level of their commitment to the sector, and why?

C. Structure and Style of Operation of Institutions

We will also want to examine the characteristics of the institutions of the R/D&I system. Some important issues could be:

What are the internal structures of the institutions (in terms of their configuration, integration, centralization, formalization, articulation/visibility, stability, etc.)?

What are their internal processes of decision making, communication, authority/status, cooperation, etc?

What are their sizes, status, resources, experience?

What are their levels of maturation and technological sophistication?

What are their ranges of products, services, etc.?

D. System Configuration (Clustering) of R/D&I Functions

As we noted in Chapter One, the various R/D&I functions may be grouped or clustered together in a variety of ways -- and they may be grouped or clustered together in differing structural configurations in or across different institutions within the same R/D&I sector or across differing R/D&I sectors. Some important issues could be:

In what form are the R/D&I functions clustered together (e.g.: linearity, parallelism, looping/contiguous, continuity/gaps, redundancy)?

Which R/D&I functions are clustered together?

What differences in the above are there across institutions within the R/D&I system?

E. Inter-Institution Linkages

The linkages between the various institutions of a system and the linkages of the system to its environment are critical. Thus, some important issues could be:

1. Linkage Characteristics

Are the linkages: strong or weak, permanent or short term? Stable or unstable? Direct or via intermediary institutions/mechanisms/associations?

Are the linkages formal or through informal communication and collaboration?

Are the linkages centralized or diffuse?

What are the system's processes for decision making and communication?

What is the nature of authority and status in the linkage process?

2. Linkage Structures and Mechanisms

What are the existing linkage structures and mechanisms?

How do they work?

Who controls them?

Are there "gaps"?

3. Boundary Conditions

Here, questions would apply both to the "boundaries" of institutions within the system and to the "boundaries" between the system and its environment.

Is the R/D&I system an open system (so that institutions relate easily, collaborate, etc.) or a closed system (so that issues of "turf" and autonomy frequently and strongly arise)?

Are these "boundary conditions" fixed (e.g.: by law; by a strong, emotion-laden history) or variable?

What are the system's processes for resolving inter-institutional conflict?

4. Linkage Consequences

Are the existing linkages functional or dysfunctional?

Do they seem to result in coordination, cooperation, conflict, or simply lack of system coordination?

Are there (or have there been) "joint venture" arrangements? Between what institutions? With what results (and why)?

F. Characteristics of R/D&I System Structure

We will want to examine various characteristics of the R/D&I system's structure. Some important issues could be:

What is the stability of these configurations over time? If unstable, why? Have the configurations changed in response to the developmental phases of the R/D&I system, of the R/D&I function(s) involved, or of the particular institutions involved?

Are the configurations appropriate in terms of phases of development, institutional goals, the personnel/financial resources of the institutions, etc.?

Are these configurations "visible" (known) to relevant parties within and/or outside the system?

Is there a balance among the R/D&I functions being performed by the system's institutions? Are there gaps? Is there unnecessary redundancy? (Note: redundancy is not "bad" per se.)

Is the structural configuration of R/D&I functions centralized or decentralized and diffused within the R/D&I system? Is it formalized or through informal associations and linkages?

IV. GOALS, POLICIES, STRATEGIES

Goals, policies, and strategies are the "action-oriented" aspects of R/D&I systems and are identified as a separate feature for precisely this reason. Goals are defined as the general purposes of the system, what one intends or derives and which may or may not happen. Perrow (1970) terms the above "official goals". Policies or "operational goals" are, according to Perrow, the "standards by which the system is judged" or the general guidelines for accomplishing official goals. Strategies are simply the means for achieving policies or operational goals.

The importance of analyzing goals, policies and strategies is that all systems have multiple and conflicting goals, policies, and strategies among subunits which can adversely affect system integration and effectiveness (c.f., Hall 1977, Lawrence and Lorsch 1967). In a detailed contextual analysis we would, therefore, be examining goals, policies and strategies at the sector, system and institutional levels. We have chosen to examine the characteristic goals, policies and strategies in terms of three categories: sources, content and aspects.

A. Source

There may be a variety of sources for goals, policies and strategies which can affect an R/D&I system and its constituent institutions. Determining whose point of view is being recognized in goal, policy and strategy formation can be quite useful to understanding system behavior (c.f., Perrow 1970). Thus, some important issues could be:

What are the sources of goals, policies and strategies which impact the R/D&I system and its institutions?

Are these sources external to the R/D&I sector, internal to the sector, internal to the R/D&I system, and/or specific to an R/D&I function?

What is the organizational or system level of the sources (e.g.: level of government; level within an organization)?

What kinds of institutions are involved (e.g.: public/private; university; profit/not-for-profit; etc.)?

What significance can/should be attached to the specific source of a goal, policy or strategy (e.g.: status, legitimacy of sources)?

B. Content

The content of goals, policies and strategies is of obvious significance. Further, the content of goals, policies, strategies is dynamic in the sense that it may vary and change over time, in different contexts, as the knowledge base changes, as sectoral needs change, as R/D&I institutions change, etc. (c.f. Katz and Kahn 1966 and March and Simon 1958). Thus, some important issues could be:

What is the content of goals, policies, strategies? How do they differ across the R/D&I functions?

Are the goals, policies strategies related to identified needs? Identified by whom?

How are the goals, policies, strategies affected by the differing needs, interests and capabilities of different sources?

What is the intended impact of goals, policies, strategies? What is the "secondary" or "indirect" impact?

Are the various goals, policies and strategies compatible or incompatible in terms of the R/D&I system as a whole and/or in terms of specific R/D&I functions or organizations?

What is the relative importance to the R/D&I system and its institutions of the various goals, policies, strategies?

How do changes in the context (e.g.: emergence or decline of institutions; changes in the knowledge/technology base; etc.) affect goals, policies, strategies (in terms of relevance, feasibility, changes in the goals/policies/strategies themselves, etc.)?

C. Aspects

Given that we know the source and content of relevant goals, policies and strategies, there are still a number of aspects of these that will significantly influence the impact on the R/D&I system.
These aspects are very much related to characteristics which are discussed at length in the Management by Objective (c.f., Ordione 1965) and general management literature (c.f., Drucker 1973, Chapter 9).

Scope -- What are the funding requirements and commitments? What R/D&I functions are involved? What institutions, other sectors, other R/D&I systems are involved directly or indirectly? What are the personnel/knowledge/technology requirements?

Time frame -- Is the time frame long or short; realistic or unrealistic?

Feasibility -- Can goals be attained or policies and strategies implemented? What changes would be required?

Flexibility -- Can required changes be made in the P/D&I system? At what cost? With what effects? Under what conditions? By whom? Is the required knowledge/technology available, or can it be developed?

Clarity -- Are the goals, policies, strategies specific and clear, or vague? Are they clear for different relevant audiences? Do different relevant audiences understand them differently?

Stability/continuity -- Are goals, policies, strategies relatively stable over time, or do they change and shift? Over what periods of time? In relation to which sources? With what effects?

Differential perceptions -- Do various relevant audiences have similar or dissimilar perceptions as to the importance, relevance, feasibility, time frames, etc. of the goals, policies, strategies?

Balance -- Are goals, policies and strategies balanced in terms of: relative priorities; sources; the various R/D&I functions and institutions; system and institutional needs related to level of maturation; etc.?

Compromises -- To what extent are the various sources willing to make compromises in order to achieve system balances, to orchestrate the system's activities, to fill gaps in the system, etc.? What mechanisms and processes are used to reach such compromises?

Appropriateness/congruence -- Are the goals, policies, strategies appropriate and congruent in relation to: the nature of the

function involved; the state of development of the system; the knowledge/technology base; adequacy of personnel/ institutional/financial resources required and available; the social/cultural environment; laws and regulations; etc.?

V. ADMINISTRATIVE PROCESSES

Administration (management) is a function of all organizations and systems, and much of the research, literature and experience relative to this function is not unique to R/D&I systems. Nevertheless, we must be aware that the relatively high degree of uncertainty and creativity involved in the processes of innovation will impact administrative processes in R/D&I systems (Bright 1964, Cetron and Goldhar, eds. 1970 and Rubenstein 1968). We will, of course, want to focus our analysis on the R/D&I system in terms of describing the existing R/D&I system, in terms of identifying those aspects of characteristics of the administrative processes function which are specific to R/D&I systems, and in terms of determining what administrative technologies can or cannot be transferred from one sector to another.

We should also note here that we include both policy and operational levels of administration/management within our understanding of the administrative processes function.

The literature on administration is quite copious, both in terms of sheer volume and in terms of identifying and analyzing a large number of aspects, characteristics and processes of administration.* Thus, analyses will generally need to be selective - - but not meager.

A. Responsibilities and Tasks

There are many responsibilities and tasks which may be part of the administration function. These may be (and are) identified,

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* Rather than cite this literature in detail, we refer the relatively uninformed reader to Drucker (1973). References in this section will deal with issues that are specific to R/D&I or seem to be different in R/D&I from "general" administration.

described and labeled variously, but would at least include the following broad categories:

- identification of goals and objectives
- establishment of policy
- formulation of strategies
- planning and programming
- mobilization and allocation of resources
- design, installation, operation and modification of management systems
- communication
- motivation

For each of these areas of administrative responsibilities and tasks, some important issues could be:*

Who has the responsibility?

Who actually performs what aspects of the required tasks?

What skills are needed?

How and by whom are responsibilities and tasks assigned?

At what level within the organization or in what part of the system are responsibilities and tasks located?

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*See Farris (1972) for a discussion of the impact of supervision on group behavior in R&D.

Upon what data are decisions made and actions taken? What are the sources of data? What degree of reliability and certainty can be ascribed to this data?

B. Administrative Relationships

Administrative relationships involve the organizationally based interactions between the personnel of an organization or system. While administrative relationships are defined in relation to organizational roles, tasks, rules, etc. (and are usually understood to be "formalized"), administrative relationships may vary in terms of clarity and preciseness, commonness of understanding between the parties involved, degree of formalization, etc. Further, attention must be given to the interpersonal/intergroup relationships between the parties involved in an administrative relationship.* We do not include here interorganizational relationships per se (though there may be some overlap), as this is part of the institutional base feature.

Some important issues could be:

What is the level of administrative relationships under consideration, (i.e., at international, national, system, institutional, intra-institutional level)? (c.f. Rosenbloom 1975)

What type of organization or organizational unit is involved, (e.g.: federal agency, a private business, an academic institution, a regional lab, a committee, a task force, etc.)?

What is the mode of the administrative relationship (e.g.: line-staff, liaison, matrix, etc.)?

What is the formal nature of the relationship, (e.g.: legal, authority, voluntary, consultative, advisory, etc.)?

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*See Farris (1972).

What are the interpersonal (intergroup characteristics of the relationship, (e.g.: collaboration, competitive, conflict charismatic, trusting/suspicious, etc.)? (Rubenstein et al. 1969)

C. Administrative System Characteristics

We may examine the administration function in terms of its characteristics as a system itself.* Some important issue areas could be:

To what extent is the administrative system centralized or decentralized? Is this appropriate or inappropriate in terms of the level of system maturation, the nature of the tasks involved, the nature and needs of specific R/D&I functions, etc.? (Rubenstein and Radnor 1963)

To what extent is the administrative system formalized by rules, regulations, policies, procedure manuals, etc.? (Hage and Aiken 1970)

Is the administrative system a relatively adaptable or inflexible (Rubenstein and Radnor)? Part of the administrative system? Under what conditions would adaptability be most needed? What costs would be involved in changing the administrative system (financial costs, system disruption, loss of personnel, etc.)?

In what ways and to what extent is the administrative system organized by/dependent upon specializations (in terms of types of specialization needed within the administrative system; impact upon the structure of the system; specialized managerial skills required (Andrews and Farris 1967)? What types of specializations? In what ways are such specializations integrated with

*As a general reference for administrative system characteristics see Burns and Stalker (1961) and Zaltman et al. (1973).

or disaggregated from each other? What level of technical sophistication is required with regard to the different spec. izations?

To what extent are administrative roles, relations, policies, selection of personnel, etc. politicized (i.e., affected by political dynamics)? What are the sources of political dynamics (e.g.: internal to the system; pressure groups; governmental)? How pervasive are the political dynamics within the system? In reference to what issues?

Is the administrative system relatively adaptable on inflexible?

Is the administrative system relatively adaptible or inflexible? (Rubenstein and Radnor) Parts of the administrative system? Under what conditions would adaptibility be most needed? What costs would be involved in changing the administrative system(financial costs, system disruption, loss of personnel, etc.)?

In what ways and to what extent is the administrative system organized by/dependent upon specializations (in terms of types of specialization needed within the administrative managerial skills required)? (Andrews and Farris 1967) What types of specializations? In what ways are such specializations integrated with or dissaggrated from each other? What level of technical sophistication is required with regard to the different specializations?

D. Characteristics of Adminstrators

The individuals who are the administrators bring certain personal characteristics to the process of administration. Among those characteristics which might be of particular significance to R/D&I could be the following: entrepeneurship, risk propensity, innovativeness, receptivity to change.

Some important issues here could be:

To what extent do the administrators of the R/D&I system reflect these characteristics (Kelly and Kranzberg 1975)? In which organizations?

Does the impact of and/or need for these characteristics differ according to R/D&I functions, different organizations within the system, different levels within organizations, different levels of system maturation, type of innovation, etc. (Zaltman et al. 1973)?

What is the impact of and/or need for other personal characteristics of R/D&I system administrators (e.g.: leadership style: orchestration, collaborati , political skills)? (Gruber and Marquis 1969, Himsworth .970, and Pelz and Andrews 1966)? Under what conditions? In relation to what parts of the system?

E. Administrative Techniques

Various administrative techniques and methods are used to perform the administrative processes function (c.f. Baker and Pound 19 4, Brandenberg 1966, Cetron and Goldhar 1970 and Rubenstein 1957). These may differ between sectors, between organizations, according to tasks involved, etc. Some important issues could be:

What administrative techniques are commonly used in the R/D&I system? (Baker and Pound, Cetron et al. 1967, and Souder 1973) How do these compare with or differ from those used in other R/D&I systems and sectors?

What administrative techniques are most relevant in terms of the level of R/D&I system's maturation, the different R/D&I functions, the nature of the tasks involved, etc.? (Baker and Pound, and Souder)

What are the conditions which help or hinder the applicability/ usability of administrative techniques across different sectors? To what extent and how is a particular technique which is useful in one sector also useful in another sector? If not, why not? (Baker and Pound, and Souder)

What are the patterns, mechanisms, dimensions of transfer and diffusion of administrative techniques from one R/D&I system to another?

VI. PERSONNEL BASE

The personnel base is a critical aspect of any organization or system. This is especially true in any R/D&I system which: 1) by definition, involves the human activity of creativity (Kornhauser 1963, Pelz and Andrews 1966, and Vollmer and Mills 1966); and 2) is highly dependent on communication among individuals for integration of R/D&I activities (Gruber and Marquis 1969, and Rogers and Shoemaker 1969). It is also clear that the personnel base feature is a highly complex feature -- one which can and must be analyzed from a variety of interactive perspectives. We will here suggest and illustrate some of these perspectives.

In broad terms, we may see the personnel base both as a resource input to the R/D&I system and as an output of the system. From the resource input perspective, we will want to know at least how the personnel base impacts the system in terms of: the skills, perspectives, and experiences, etc. which they bring to the system (Kornhauser, and Pelz and Andrews); whether personnel needed by the system are available or not (Holloman 1966 and Kornhauser) and the extent to which individual goals and objectives are similar or dissimilar, compatible or incompatible with goals and objectives of an R/D&I system or organization (Badawy 1973, Kornhauser, and Shepard 1954). On the other hand, the personnel of an R/D&I system may be seen as an output of the system in the sense that the personnel do change as a result of training they receive, their socialization into the system and its organizations, the learning which occurs through experiences (Vollmer 1966), and the obsolescence which occurs through lack of adaptation to a changing knowledge environment and/or lack of rest and stimulation of skills.

A. Types of R/D&I Personnel: Needs, Availability and Sources

One of the first things we would want to know about an R/D&I system's personnel base is the types of personnel (and personnel "expertise") which are needed by the system.* Some important issues could be:

What types of personnel are currently needed (e.g.: administrative/technical; scientists/engineers/machine operators; skilled/semi-skilled/unskilled; etc.)?

What types of personnel are needed in terms of the specific nature/needs/requirements of: the different R/D&I functions; the particular sector; the type of technology involved; the particular organization (or type of organization -- e.g.: government agency, private industry, university, R&D organization, user organization, etc.); governmental requirements (e.g.: age, sex, race anti-discrimination laws); etc.?

What specializations are needed? What mix, mass and balance of skills and specializations are needed?

What time lines are involved either for training and development personnel or for creating sources of personnel (e.g.: how long does it take to train a researcher, a disseminator, a technical specialist, etc.; how long does it take to create programs and institutions to provide such training)? What processes are required to achieve this training and development?

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* These issues are typical of those addressed by any organization or system in manpower planning -- c.f. W.F. Glueck, Personnel: A Diagnostic Approach, 2nd ed., Dallas: Business Publications, 1977 and E. Vetter, Manpower Planning for High Talent Personnel, Ann Arbor: University of Michigan, Institute of Industrial Relations, 1967.

What has been the historical pattern of the system's personnel needs?

What are the projections for future needs?

In what ways are current and future needs likely to be affected by such factors as: technological changes; changes in the economy; funding patterns; needs of the sector; marketplace demands and requirements; turnover rates (and what are the causes for the turnover rate); changing ages of current personnel over time; retirement rates; existing or anticipated laws; obsolescence, aging; etc.

We would also want to know about the availability and sources of needed R/D&I system personnel. Some important issues could be:

Are the needed personnel available, in short supply, or in oversupply?

What has been the historical pattern of the availability of needed personnel?

What are the projections for future availability of needed personnel?

What is the impact (short term and long term) on the system of the level of availability of needed personnel?

In what ways will availability of needed personnel be impacted by such factors as: the ability of the R/D&I system to attract and retain needed personnel; funding patterns; technological changes; retirement rates; governmental regulations?

What are the existing sources for needed personnel (e.g.: universities and colleges; technical institutions; internal organizational training programs; second career personnel; etc.)? Do these sources exist within or are they external to the sector? Are they adequate in terms of either number, quality or particular types of personnel needed? If not, can the system provide such sources?

What environmental factors affect the personnel base (e.g.: population growth rates, laws and regulations, societal norms and values, state of the economy, popularity of and support for various fields of knowledge, etc.)?

B. Professions and Occupations

In addition to looking at the personnel base from the general perspective of the R/D&I system, we will need to examine as separate systems those specific professions and occupations which are relevant to the R/D&I system (Becker and Carper 1956, and Kornhauser 1966).

The development of professions and occupations is a differentiation process and as such has all the benefits of segmentation of tasks and specialization of knowledge and all the difficulties of achieving unity of effort for activities requiring collaboration among different professions and occupations. Shepard (1954), Kornhauser, and others (Badawy 1973, and Barth 1973) have shown, for example, that professional (or occupational) socialization can lead to a lack of congruence between a professional's values and those of his/her organization. Furthermore, there are value, goal, time orientation, etc. differences among various professions and occupations (Pelz and Andrews 1966). These differences are important to the integration of work within the R/D&I as well as to the linkages of the system and its components to relevant sub-environments (especially the knowledge/technology environment). Issues, therefore, are directed at the degree of differentiation of professions and occupations and the linking processes acting among professions/occupations and between professions/occupations and their relevant sub-environments. The questions which follow deal (in section B) with the issue of differentiation and integration at the systems level (i.e., between the R/D&I system and its immediate environment), with issues of differentiation (in C), and with integration within the R/D&I system (in C).

To what extent are the various professions and occupations specific to the sector in which the R/D&I system exists (e.g.: the teaching profession of the education sector)? To what extent are they sector spanning (e.g.: computer technicians)? To what extent do they have both sector spanning and sector specific characteristics (e.g.: researchers within a specific discipline, whose research skills/methodologies may be at least partially sector spanning but who are socialized in/committed to a specific sector)?

Are there organized associations related to the particular occupations and professions? What status and power do they have? Are their goals and values compatible or incompatible with the goals and values of the R/D&I sector, system and/or organizations? What is the level of commitment of these associations to a particular R/D&I sector or system?

What are the entrance requirements/standards/regulations for these professions and occupations? Who sets them? Who implements and monitors them? Who evaluates potential personnel? What is the impact of these requirements/standards/regulations on the availability of needed personnel?

What are the knowledge life cycles for these professions and occupations?

What career paths are provided within the R/D&I system? Are there alternative career paths within the system (e.g.: between organizations, between R/D&I functions)? Are there alternative career paths available in other sectors or R/D&I systems? What are the mobility patterns within the R/D&I system, between professions and occupations, between sectors?

What are the status systems within the R/D&I system? Between R/D&I systems?

C. Characteristics of the System's Personnel

Thus far, we have focused on the personnel base feature in terms of the R/D&I system. It will also be important to have some knowledge about the personnel themselves (Barth 1973, Pelz and Andrews 1966, and Vollmer and Mills 1966). Here some of the major issues could be:

What are their levels of commitment to the sector, the R/D&I system and particular organizations?

What is the nature of their motivation (e.g.: financial, status, responsibility, creativity, etc.)? Are these motivations "matched" with the incentives provided by the system?

What are the values of system personnel?

What are the goals and objectives of system personnel? Are these compatible or in conflict with goals and objectives of the R/D&I system, functions and institutions?

What perspectives, experiences, biases, etc. do the personnel bring to the R/D&I system (in terms of their background)?

How does the creativity ability of personnel tend to change, over time, in response to varying institutional and other environmental conditions (Andrews 1967)? What can be done to increase the availability of creative personnel (Watson 1975)?

D. System Activities Related to the Personnel Base

It will be important to know how the R/D&I system responds to its personnel needs. Obviously, here our concerns will overlap a portion of the administrative processes function and are concerns commonly addressed by personnel functions.*

*See Glueck, Personnel: A Diagnostic Approach and E. Vetter, Manpower Planning for High Talent Personnel.

Here, some important issues could be:

What is the nature, extent and adequacy of monitoring, forecasting and planning for the system's personnel needs?

What is the nature of the system's incentive systems (e.g.: financial, position, status, promotion; formal/information; etc.)? Are they relevant to the needs and motivations of personnel? How do they differ across R/D&I functions and institutions?

What are the processes and criteria for recruitment and selection of personnel?

What is the nature of the socialization process for system personnel?

What is the type, extent and methodologies of training and development?

Does the system deal with personnel obsolescence through replacement or training?

Who sets, implements, monitors R/D&I system requirements in relation to tasks of the system, performance requirements and standards, etc.? Is this done internally within the system or is this imposed externally (e.g.: by governmental laws, regulations, agencies)? How are these "enforced"?

How is information about the personnel base disseminated/diffused throughout the R/D&I system? By whom? Who uses such information? Are there significant "gaps"?

VII. FUNDING

Funding is a feature which, at least at a minimum level of sophistication, is easily recognizable as being significant to the process of innovation. Indeed, in our analysis of other features, we have referred repeatedly to issues of cost. However, while analysis of funding must obviously include considerations of cost, analysis of funding must also include consideration of sources of funding, availability/obtainability of funding, the process and constraints involved in obtaining funding, the stability of funding, patterns, distributions, and so forth.

The discussion herein is an extension of Section I.C. "Economic Environment" in that it addresses issues related to the interrelationships between the R/D&I system and significant components of its economic environment, namely funding sources. We are also concerned with the "causal texture" of the funding environment, which is the relationship among funding sources and between funding sources and other components of the system's environment (economic, legal/political, etc.).

The availability and accessibility of capital resources has been shown to be of considerable importance to R/D&I in education (Committee for Economic Development 1968); industry (Diebold Group 1973, Mansfield 1968, Radnor et al. 1970 and Shepard 1969); agriculture (Carter 1970); and government (Denver Research Institute 1973, Radnor et al. 1975, and The Urban Institute 1971) in both developed and underdeveloped economies (Himsworth 1970 and Shills 1967). The processes, incentives and barriers involved in obtaining funding for R/D&I while well recognized have only recently been examined in any detail (Denver Research Institute 1973, Diebold Group 1973, Arthur D. Little 1973, Roberts 1969, and the Urban Institute 1971). This research unfortunately,

tends to consider only one issue, namely, the availability of government funding. Other, relevant issues such as the stability of funding, laws and regulations, risk, urgency, etc. have received only cursory treatment, even though there are indications that such factors are significant influences on R/D&I (c.f. Mansfield 1968 and Rogers 1962).

For simplicity we have divided the discussion of potential funding issues into two parts: 1) the characteristics of the sources of funding, and 2) the characterics of the funding of R/D&I.

A. Sources of Funding

Clearly, the characteristics of the sources of funds will affect availability and accessability. Some of these characteristics would include size of the sources (in terms of personnel and financial resources), goals, procedures, organizational structure and background and experience of source personnel (c.f. Holloman 1966) and relevant questions could include:

What are the major sources of R/D&I funding: government sources (and from what level of government: local, state, federal, governments of other countries and international organizations); foundations; private organizations not involved in the R/D&I system or sector; private organizations which are part of the R/D&I system or sector; venture capital organizations, etc.?

In what ways are the sources subject to such dynamics as the waxing and waning of national issues; political shifts; the general economic climate; degree of risk involved? Do such dynamics affect the various funding sources similarly or differentially?

What is the extent of commitment of the funding source (sources) to R/D&I? What is the pattern of funding (i.e., what R/D&I functions, what institutions, what innovations or areas of concern are funded)?

What factors influence whether funding will be provided for R/D&I and how they can be used (e.g.: laws and regulations; the degree of risk involved; the perceived importance or urgency; differences about return on investment criteria; etc.)?

To what extent do sources of funding integrate their activities? Are their procedures similar or dissimilar?

What are the financial conditions of the funding sources? How much of their funds are available for R/D&I?

What is the level of funding with respect to the sector, the R/D&I system, each of the R/D&I functions, specific areas of R/D&I concern (e.g.: the aerospace/moon landing concern of the 60s; filling "gaps" in the dissemination system), specific programs/projects, and as relevant, specific institutions?

Is funding for programs/projects stimulated by field-initiated proposals or by funding agency plans/programs/requests-for-proposals?

What kinds of return on investment do the funding sources expect (e.g.: financial, new products, system building)? Within what time frames?

What are the policies of the funding sources with respect to R/D&I? With respect to a specific R/D&I sector, system or institution?

On what basis is funding provided (e.g.: historical basis; percent of income/sales; etc.)?

What types of funding are available from the various funding sources (e.g.: appropriations from legislative bodies to other government agencies; grants; contracts; sales of products and services; etc.)?

Are funds made available on a "sole source" or only on a competitive bidding basis? Are funds provided on a fixed price or a cost-plus basis?

How do the types of funding differ in terms of the amount of discretion and flexibility the recipient may exercise in the use of funds?

Are the granting agencies able to respond to short-term or emergency R/D&I needs? If not, is this due to structural or procedural issues?

Are funding source personnel sympathetic to the R/D&I system or sector? Do they understand the particular problems and needs of R/D&I?

B. Characteristics of the Funding of R/D&I

The characteristics of the funding of R/D&I important to this analysis are considered in terms of both actual and required. These characteristics include not only the level of funds, but the stability, balance, etc. (c.f. Charpie 1967, Mansfield 1968, and Rubenstein, et al., 1974). Some important issues, therefore, could be:

Is the level of funding adequate to meet a particular R/D&I system need or the requirements of a particular innovation?

Is the level of funding balanced across the R/D&I functions in terms of the respective levels of funding needs of the R/D&I functions and in terms of the total flow of innovation from knowledge production to knowledge utilization?

Is the level of funding adequate to meet the expectations of the funders?

What can/should be done within the limitations of the existing, given level of funding?

Are there maximum levels beyond which funding cannot be used effectively? (For example, the amount of funding that can be effectively utilized within the basic research function will be limited by the extent of the existing personnel/ institutional bases.)

Are there minimum levels of funding needed in terms of (for example) the costs in a particular area of innovation, the need to maintain (but not expand) the existing personnel/ institutional bases, etc.?

What factors must be considered in order to determine the level of funding needed (e.g.: the capital, operating, personnel and maintenance costs involved during the various stages of the R/D&I process; the nature of the innovation involved; whether or not system building is involved; etc.)?

To what extent have funding patterns tended to "shape" the R/D&I system in terms of which issues/concerns are emphasized or neglected; which R/D&I functions are developed or neglected; the focus, character and strength of R/D&I institutions; etc.? Is the type of funding available appropriate to the needs of the R/D&I system, function or institution? To the type of program or project being funded?

Has funding tended to be stable or unstable?

What has been or would be the short and long term impact of funding instability in terms of: R/D&I system stability and capability; the personnel and institutional bases of the R/D&I system; short and long term return on investment; sunk costs; whether or not there will be innovation "outcome" or "results"; the adequacy of innovation outcomes/results; etc.?

Over what period (length) of time is funding stability needed?

Is there a range of funding levels within which funding may fluctuate without severe short or long term impact? What is this range?

Do these considerations vary across the R/D&I functions; across the institutions of the system; in terms of the relative state of development (maturation) of the R/D&I system, functions, institutions? In what ways?

Finally, with respect to cost patterns we may ask what are the amounts, patterns of expenditures over time, distribution across R/D&I functions and institutions, etc., for which funding will be required? How will these patterns and requirements influence the funding process?

What types of costs will/will not be allowable under various funding arrangements? To what extent can costs be shifted to conform to available funding constraints?

How well can costs be estimated (amounts, when required, etc.) to permit proper funding programs? What will be the effects on funding requirements for change in cost patterns?

VIII. INFORMATION FLOW

Information flow or communications is central to the functioning of any system. In its broadest sense, information flow is the primary linking or integrating process among the individuals, groups and institutions comprising the system and between the system and its environment (Katz and Kahn 1966, and Thompson 1967). Because of the significance and implications of the concept of information flow for systems functioning, it is considered as a separate feature of the contextual analytic framework. Because the product of an R/D&I process is essentially information, the issue is of central importance to R&D and has been the subject of considerable research (Allen and Cohen 1969, Goldhar et al. 1976, Holland et al. 1976, Taylor and Utterback 1975).

There are many and varied definitions of the concept of information flow (Porter and Roberts 1976). To try to deal with the definitional problems, however, is outside the scope of this discussion. Since our purpose is to better understand R/D&I systems and their functioning, it is useful to take the broadest possible definition of information, whether or not by doing so we are overlapping issues dealt with in other features. The process of contextual analysis, as we discussed in Chapter One, is iterative with parts of the process being repeated as new understandings or insights are gained. By broadly defining information flow, new insights or understandings may be provided relevant to other features.

Most general information flow or communication models view information flow as "an attempt to share meaning via the transmission of messages from sender to receiver" (Porter and Roberts 1976). The key elements of this process are who says what, by which channel, to whom and with what effect (Robertson 1971). In the context of R/D&I, Kegan

(1966) has developed a "technology transfer model" based on information flow between a source and "intended destination". This model shown in Figure 1 summarizes information flow as an interaction process (See also Myers and Marquis 1969, and Utterback 1973).

Information flow is, however, more than the exchange of information. The concept also subsumes social processes, such as influence, control, and cooperation. Another element, therefore, is the social system in which information flow takes place. As Katz and Kahn (1966) state: "communication needs to be seen not as a process occurring between any sender and potential recipients, but in relation to the social system in which it occurs and the particular function it performs."

Another significant characteristic of information flow in R/D&I is that it occurs over time. The element of time is involved throughout the R/D&I process from need identification to evaluation research and including the stages in between (Rogers and Shoemaker 1971). In carrying out particular R/D&I functions and integrating activities among functions certain patterns of information flow and networks of interacting personnel are structured and/or develop by experience. It is the discussion of time which distinguishes the analysis of information flow in R/D&I from the more conventional areas of "communications research" (Rogers and Shoemaker).

Some potential issues relevant to each of the above elements of information flow are described below:

A. Sources of Information (Who)

Thayer (1967) contends that there are three factors of importance in understanding any two person interaction. From the point of view of the source these factors are: 1) the source's concept of self, 2) the source's concept of the receiver, and 3) the source's concept of the purposes of communication. Some potential issues, therefore, are as follows:

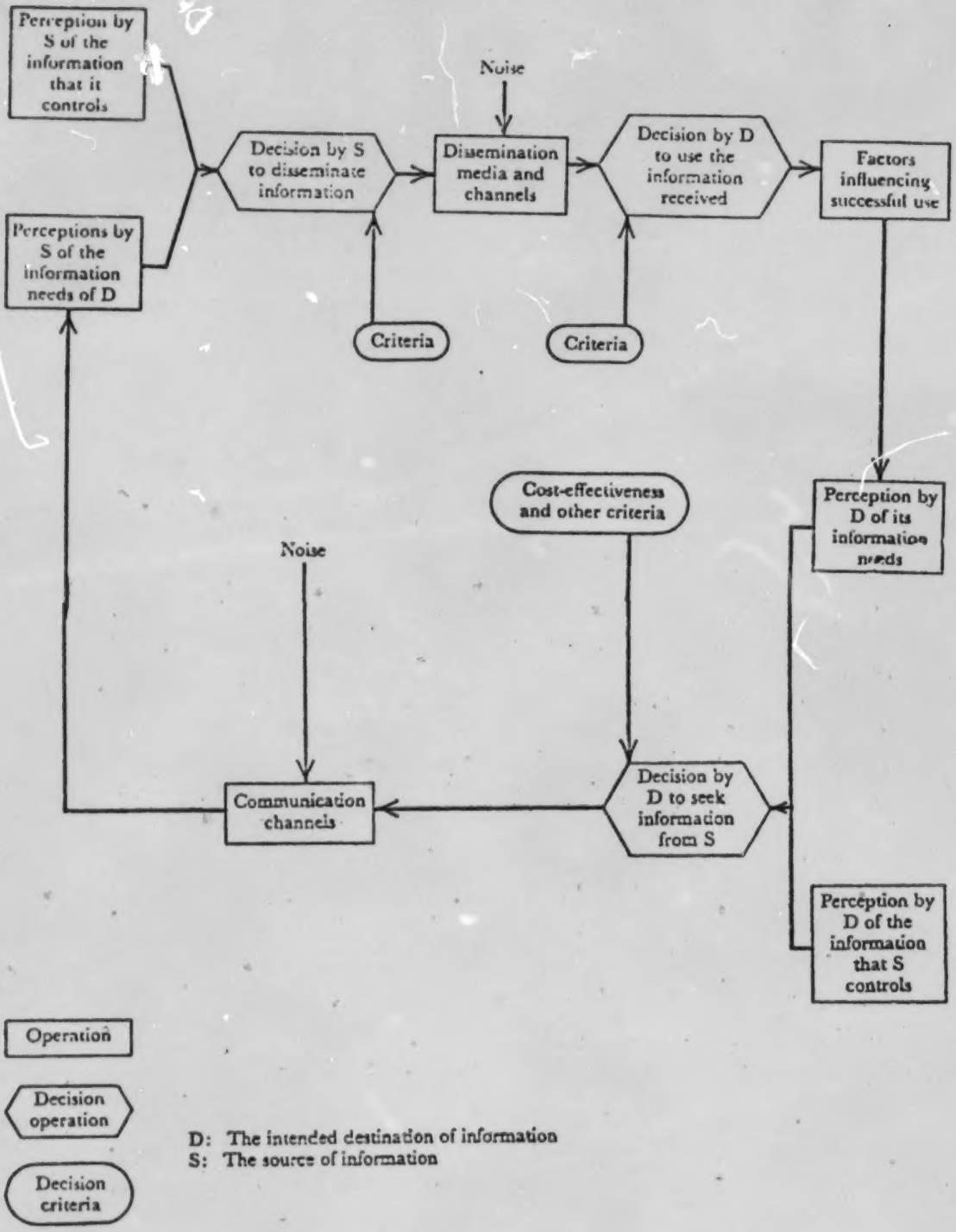
Perception by S of the information that it controls
Perceptions by S of the information needs of D
Decision by S to disseminate information
Noise
Dissemination media and channels
Decision by D to use the information received
Factors influencing successful use
Criteria
Criteria
Cost-effectiveness and other criteria
Noise
Perception by D of its information needs
Communication channels
Decision by D to seek information from S
Perception by D of the information that S controls
Operation
Decision operation
Decision criteria
D: The intended destination of information
S: The source of information

Figure 1

"A Technology Flow Model"*Kegan (1966)

Who are the sources of information (individuals or institutions) within and external to R/D&I and to the institutions in the R/D&I system? Are they many or few? Centralized or diffuse?

From what frames of reference (disciplines, value sets, etc.) is information sent?

How do these sources view themselves in relation to receivers (e.g.: important in their own right or dependent upon receivers)?

What perceptions do sources have about the purposes of receivers?

What expectations do sources have about how information will be utilized?

What purposes do sources have for sending information?

Does information flow accomplish the purposes of sources? If not, why not?

Are there other potential, relevant sources of information that are not sending information? If yes, why? Who?
Is there relevant information not being sent? If not, why not? What information?

In what ways does the nature of the sources affect the potential availability of needed information? The potential validity and relevance of the information? In what ways might the potential biases and limitations of perspectives of the sources affect the information they provide?

Who is not receiving needed information? Why not?

B. Types of Information (Says What)

The type of information is related to the characteristics of innovations in the R/D&I system which is discussed in the next section (IX).

One important generic aspect for R/D&I processes involves the question of idea flow in R/D&I as a manifestation of information flow.

How is the flow of ideas influenced by organizational constraints on information flow (e.g.: up the hierarchy, or between organizations/departments) (Baker et al. 1967, Holt 1975, Utterback 1971).

C. Information Flow Channels (By Which Channel)

In order for information to get from the sources to the recipients, there must be channels for information flow. Some important issues could be:

What channels exist?

Are the channels formal (e.g.: newsletters; dissemination organizations; journals; papers presented at professional meetings; formalized inter-organizational and intra-organizational channels and procedures for communication; etc.) or informal (at meetings; by telephone as the occasion arises; invisible colleges; etc.)?

Are the channels appropriate? (Do they connect the right sources with the right recipients)?

Are single or multiple channels used to transmit the same information (e.g.: an article is printed in a journal, which is then stored in a data bank and summarized in a newsletter)?

Are the channels adequate? (Are there gaps? Can the channels "carry" enough information? Do the channels "distort" the information? If so, in what ways? Do the channels "screen" or synthesize information?)

Are the channels used? (If not, why not? Are they designed so that recipients can assess them? Are they known to potential users?)

Are information gatekeepers used? How do they play this role? Who becomes a gatekeeper, under what conditions? (Allen 1971, Taylor 1975)

What types of boundary spanning activities are to be observed? How do such boundary spanning roles as "project manager" influence information flows? (Keller and Holland 1975, Organ and Greene 1972)

D. Receivers of Information (To Whom)

The characteristics of receivers important to information flow are similar to those of sources, that is, the receiver's self concept, concept of source, and concept of the purposes of communication (Thayer 1967). It is important to recognize that these factors are important only in relation to the source and the effectiveness of information flow. There is nothing inherently bad or good about a particular receiver's (or source's) concept of self, etc. In the following, we will utilize some of the issues addressed in Section VIII A, dealing with characteristics of information sources in comparison with characteristics of receivers, to determine the effects of incompatabilities or perceptions between sources and receivers. Some potential issues therefore, are:

Who receives information (individuals and institutions)? Are they many or few? Centralized or diffuse?

From what frame of reference is information received? Are these frames of reference compatible or incompatible with receivers (i.e., do differences cause "noise" in the system)?

How do receiver's view themselves in relation to sources? (e.g.: important in their own right or dependent upon sources)? Do differences in self concept among source and receiver create difficulties in information flow?

What perceptions do receivers have about the purposes of sources?

What expectations do receivers have about how information will be utilized? Are these expectations similar or dissimilar to those of the sources of information? Compatible or incompatible? If incompatible, why? What is the effect of this incompatibility on effective information flow?

What purposes do receivers have for receiving information? How do these purposes differ from those of sources?

Does information flow accomplish the purposes of receivers? If not, why not?

Are there potential relevant receivers of information not currently receiving information? If yes, why? Who?

Is there relevant information not being received? If yes, why? What information?

E. Utilization of Information (With What Effect)

We previously discussed the expectations about how information will be utilized. Clearly we are also concerned with how it is actually utilized. Some potential issues, therefore, are:

How is information actually used? Or is it used? If not, why not?

Are the expectations of sources, receivers or both realized in the utilization of information? If not, why not?

F. Control and Access (Social system)

The social system in which information flow takes place is manifested in or affects control of and access to information (c.f. Katz and Kahn 1966). The issue of control is not simply one of authority or position. It is also a matter of the types of barriers or blockages that effectively limit the flow of information. The manner in which information is stored and access can also be important in determining what is communicated to whom.

Some important issues could be:

Who determines what information will be sent or received; by whom and to whom; when; and what channels and methodologies can/will be used?

Is information flow open, or is it limited by laws, regulations, political considerations, cost, suspicion, lack of awareness by senders of the need a recipient has (or, vice versa, lack of awareness by a recipient that information exists, or what is the source for information, or what channels to use)?

How is information stored and accessed/retrieved? Is information storage/retrieval automated?

Who determines: what information will be stored; how it will be stored; what the retrieval mechanisms/processes will be; who will have access to information?

G. Patterns of Information Flow (Over Time)

We will need to ascertain the patterns of information flow which emerge over time in order to determine both the nature and adequacy of information flow. Some important issues could be:

What are the primary patterns of information flow in terms of who communicates with whom? Is the information flow unidirectional? Two-way but between isolated sets of senders/receivers? Multidirectional among a variety of senders and receivers?

What sources of information and channels of information flow are or are not used?

What methodologies and techniques are most used? To what extent does the information flow tend to be formal or informal?

How and by whom is the information flow process initiated? (Do users contact producers? Or do producers contact users? etc.) Who seeks information and who does not? Why?

A specific issue of some interest here involves the interdepartmental flow of information between R&D and other functions (e.g.: marketing or production). Some specific questions are:

How does intergroup climate affect inter-departmental information exchange (Barth 1971, Biller and Shanley 1975, Burns 1961)?

How can couplings and interfaces between such functions be improved (Rubenstein et al. 1969, Steade 1966, Young 1973)?

H. Networks of Information Flow (Over Time)

The second factor related to the dimension of time is the development of networks of communication or information flow. Such networks may be formalized or may be informal, centralized or diffuse, separated from or integrated with each other. Here some key issues could be:

Where, to what extent and by whom are such networks needed?

To what extent do such networks exist?

In what ways are the networks connected with each other?

What networks are external but relevant to the R/D&I system?

What impact does the existence or lack of such networks have on the R/D&I system?

In what ways are the networks effective or ineffective?

Who performs the various information processing roles within the networks (e.g.: the role of "gatekeeper")?

IX. INNOVATIONS

All of the contextual features we have discussed thus far have assumed the existence of some innovation(s) -- and some understanding of the innovation(s) involved must indeed be incorporated in the discussion of any of the contextual features. However, this very centrality of the innovations themselves warrants considering "innovations" as a separate feature to insure that adequate attention is given during any analysis. Depending on the type and purpose of the specific analysis, the focus may range from consideration of a specific innovation to the broad range of innovations relevant to a particular R/D&I system or sector.

Definitions of innovations vary greatly in the literature. The term has been used to denote both items and processes. In this section we consider innovations as objects, ideas or practices. Further, we must be concerned with not limiting what is or is not an innovation so as not to restrict the resulting analysis.

Essential to the concept of innovation is the discussion of novelty or newness. Barnett (1953) defines innovation as "any thought, behavior or thing that is qualitatively different from existing forms." What constitutes novelty or difference from existing forms, however, has been the subject of disagreement among researchers and research traditions.

"Innovations" has been used to refer to items which are new in a state-of-the-art sense (c.f. Kelly and Kranzberg 1975) as well as items perceived as new by the adopting unit (Rogers and Shoemaker 1971).

Both objective newness and perceived newness are important considerations for the purposes of contextual analysis. Objective newness is important to the efficiency of R/D&I activities. Its importance is demonstrated in the classic question of library search versus experiment.

Perceived newness, on the other hand, is an important factor in determining indivudual response to an idea, practice or object at all stages of the R/D&I process.

The analysis of the innovations feature would include at least three general types of considerations: requirements for the innovations, characteristics of the innovations, impact and benefits of the innovations. Naturally, these overlap to some extent. The diffusion of innovations is dealt with in Part Three (Feature No. XIV).

A. Requirements for the Innovations

R/D&I system elements and functions constitute a set of boundaries or filters through which innovations must pass. These innovations, in turn, impose certain requirements on these elements and functions, which in some cases require system change to accommodate innovations. The implementation/utilization of an innovation, for example, is by definition a change in user elements and functions. Similar, although often more subtle, changes may be required by an innovation or innovations in other system elements and functions.

There is a rapidly growing and diverse body of literature which seeks to explain the differential response to and the differential impact of innovations on R/D&I system elements and functions. Important overviews of various innovation research traditions are provided by Havelock (1969), Kelly and Kranzberg (1975), and Rogers and Shoemaker (1971). Despite the diversity of approaches and interests in varying R/D&I sectors (i.e., agriculture, education, industry, etc.) some common albeit general findings as to possible system requirements for innovation have emerged. These possible requirements are as follows:

1) there is an existing and recognized need;

2) there are adequate financial and personnel resources available;

3) there is a technological capacity to absorb innovations (i.e., there is a relation between the innovations and the system's existing operations);

4) there is an organizational capacity (structure and capability) to absorb innovations;

5) there is an open, receptive management climate and top management support for innovation; and

6) socio-cultural and political/legal environments are not significantly antithethetical to innovation.

Some of the possible issues related to these user requirements are; Therefore:

Need identification - - What needs would the innovation meet? Whose needs? How were the needs identified? By whom?

Level and scale of R&D effort - - What scale of costs are involved? What level of complexity and sophistication of technologies is involved? How many and what type of personnel and institutions are involved? What length of time is required?

System management - - What impact does the innovation have on the management of the R/D&I system in terms of coordination/orchestration/communication efforts; nature/amount/type of involvement with organizations external to the R/D&I system and sector? -- With what other technologies or aspects of the R/D&I system must the innovation be integrated or coordinated? What modifications in the existing R/D&I system or specific technologies/facilities must be made for the innovation to be

utilized? What other R/D&I system technologies and facilities must be "in place" before the innovation can be developed, produced, disseminated, utilized?

State of the arts - - What state of the arts of relevant technologies is required by the innovation? What is the current state of the arts, and is it adequate or not?

User requirements - - What do users expect from the innovation? How must the innovation be developed and produced in order for it to be compatible with the user's system and capabilities? (Or, alternatively, what changes would be required within the user system?)

Constraints - - What governmental laws and regulations impose requirements on the development, production, dissemination, utilization of the innovation? What requirements? At what level of government? What requirements are imposed by other organizations (e.g.: professional associations; the participating R/D&I institutions)? What social/societal constraints exist and how would they impact the innovation at <u>any</u> stage of the knowledge production/knowledge utilization process? Are the required resources available or obtainable?

B. The Characteristics of the Innovations

The characteristics of innovations have been identified as important factors which typically act at the latter stages of R/D&I processes (i.e., marketing/distribution/dissemination/diffusion, acquisition and implementation/utilization). There has, however, been only limited systematic research on the attributes of innovations and their relative importance in R/D&I. The major traditions which have explicitly dealt with characteristics of innovations are the diffusion research, industrial (economic), and research-on-research

traditions. Although these traditions have dealt with different types of adopters (i.e., individuals and industrial organizations) and sectors (i.e., agriculture and industry) their research has resulted in the development of quite similar attributes of innovations (cf., Mansfield 1966, Rogers and Shoemaker 1971 and Rubenstein et al. 1974).

Kelly and Kranzberg (1975) have shown the similarity of diffusion and industrial research traditions in their development of characteristics of innovations. The research-on-research tradition, while drawing on both diffusion and industrial research traditions, has tended to further explicate these characteristics. In the following, we have incorporated the work of Rubenstein et al. into the Kelly and Kranzberg discussion of diffusion research based on Rogers and Shoemaker (1971) and industrial (economic) research based on Mansfield (1966). It should be noted that we have singled out one of the characteristics of innovations termed relative advantage by Rogers and Shoemaker and encompassing Mansfield's concept of economic advantage for consideration as a separate sub-feature. (See Section IV.C)

Mansfield	Rogers and Shoemaker	Rubenstein et al.
4) Initial Uncertainty	1) Compatibility	a) with existing Production Processes/Organization
		b) with Corporate Goals
		c) with Available Financial and Personnel Resources
		d) with Available Skills
		e) with Existing Authority/ Power Structure
		f) with Technological State-of-the Art (i.e., need for coll teral innovations)

Mansfield	Rogers and Shoemaker	Rubenstein et al.
		g) with Projected Market (Life Cycle)
		h) with Government Laws, Regulations and Policies
	2) Complexity	a) Technical Sophistication
		b) Complexity of Design
	3) Observability	a) Availability of Technical Information
		b) Novelty of Technical Approach
		c) Type of Innovation
		d) Availability of Information about the Cost of Attaining Market Acceptance and Desired Market Share
		e) Availability of Information about Sales Potential
		f) Availability of Information about Development Costs
B) Initial Commitment	1) Trialability	a) Extent to Which Innovation may be Experimented with on a Limited Basis
		b) Initial versus Total Costs

In the following we have structured possible issues in terms of Rogers and Shoemaker's characterization of innovations:

Compatibility:

How well does the innovation fit into existing processes, technologies, facilities, skills, etc.?

How well does the innovation fit projected markets in terms of

its life cycle, obsolescence, etc.? Is there an "after-market"?

Is potential usage specialized or generalized? Is the innovation one which can only be used by a few people or institutions (because of skills or facilities required; costs; limited interest in using the innovation; applicability only to a limited type of situation)? Or can the innovation be used by many people in a wide variety of settings? Is the innovation germaine only to a single sector? Can the innovation be modified for more widespread usage?

What level of quality is needed? Is the level of quality requirement imposed by the nature of the innovation itself, by users, by governmental laws/regulations, by safety considerations, etc.?

What are the relevant safety considerations? How do they affect the innovation itself or the processes of developing/producing/utilizing the innovation?

Are there legal/social factors which could limit the development and resulting market for innovations?

Complexity:

Is the innovation relatively simple or complex? What level of complexity is involved in implementation/utilization and implementation/utilization support services?

What is the range of the reliability of the innovation? How reliable must it be?

Observability:

Is the innovation a "hardware" item, "software" item, a process, etc.?

To what extent is information about cummulative costs and benefits of innovations available (i.e., costs to develop, produce, disseminate, acquire, operate, maintain, provide support services and replace the technology and potential market size, share, etc.).

Trialability:

Can the innovation be tested? With what degree of certainty? At what point in its development, production, implementation? By whom can it be tested?

What are cumulative costs (i.e., to develop, produce, disseminate, acquire, operate, maintain, provide support services, replace, etc.)? Are the costs spread or concentrated in terms of: R/D&I functions; particular organizations?

C. Impact and Benefits of the Innovations

Impacts and benefits are the ultimate outcomes of the R/D&I process and, therefore, require consideration as a separate sub-feature or characteristic of innovations. For innovations that are at early stages in the R/D&I process benefits and impacts are perceived characteristics which have been found to be important determinants of user adoption behavior (c.f. Rogers and Shoemaker 1971).

Some important issues could be:

Who benefits from/is impacted by the innovation (users, personnel, environment, etc.)?

What is the nature of the benefits and/or the impact?

Are there negative "side effects"? What are they? Who or

what aspect of the R/D&I system is negatively affected? Can the negative effects be controlled? Are they "acceptable"?

Are the benefits short term or long term? How quickly and for what continuing period of time will the innovation have impact? Does the time frame for benefits/impact differ relative to different R/D&I functions, different institutions, different R/D&I system needs and issues?

PART THREE

R/D&I FUNCTIONS

To understand the R/D&I systems, one must understand the distinct functions involved in producing knowledge, translating this knowledge to useful forms and utilizing knowledge. CISST's conceptualization of these functions are need identification, generation/research, development, production, marketing/distribution/dissemination/diffusion, acquisition, implementation/utlization, support services and evaluation research. That these or similar functions exist and are important to knowledge production/knowledge utilization can be shown from the results of the increasing body of "diffusion", "technology transfer", "innovation", or "technological change" research. The R/D&I functions considered in the CISST analytic framework represent a synthesis of these various research traditions, with their varying units of analysis and foci consistent with the systemic nature of knowledge production/knowledge utilization.

The relationship between the functions considered in the analytic framework and the functions considered important in other models relevant to R/D&I is shown in Table 1. The models in this Table are representative of the dominant traditions of research or research areas of interest in R/D&I. Three of the models deal with knowledge utilization; one considering the organization as the adopting unit (model A), and two the individual (models B and C). Model D deals primarily with the knowledge production process. The final model, E, focuses on the transition from knowledge production to knowledge utilization. In brief, the CISST R/D&I functional model has the following characteristics and assumptions:

1) Problem solving (model A) and research and development (model D) are viewed as interrelated processes. For example, if there are separate Source and User subsystems, the source must recapitulate or simulate user problem solving and the user must understand (and

Table 1

FUNCTIONS INVOLVED IN THE R/D&I PROCESS

Process Models	Need Identification	Generation/ Research	Development	Production	Marketing/ Distribution/ Dissemination/ Diffusion	Aquisition	Implementation/ Utilization	Support Services	Evaluation Research
A. Problem Solving Approach (Myers and Marquis 1969)	Recognition →	Idea Formulation →	Problem Solving →	Solution →	Diffusion →	Utilization			
B. Individual Adopter Approach- Renal Sociology (Rogers 1962)	Awareness →				Awareness ↓ Interest →	Evaluation ↓ Trial → Adoption →			Adoption / Rejection
C. Individual Adopts Approach- Marketing (Robertson 1971)	Problem Perception				Awareness ↓ Comprehension ↓ Attitude → Legitimation ↓	Trial → Adoption →			Disonance
D. Research Development & Dissemination (as reported in Havelock 1969)		Basic Research ↓ Applied Research →	Development & Testing of Prototypes →	Mass Production and Packaging →	Mass Dissemination Activities →	The User			
E. Information Use Approach (as reported in Zaltman & Duncan 1977)	Need Assessment →	Research Questions →	Conduct of →	Memory of Innovations →			Implementation →		Evaluation and Research

stimulate) research and development processes (Havelock 1969).

2) Decision making in a systems or organizational context is more than the aggregate of individual decisions (models B and C). Existing system or organizational models (A, D and E), however, either ignore or deal only peripherally with decision making (acquisition), as well as other knowledge utilization functions such as implementation/utilization, support services and evaluation research. These functions are directly considered in the CISST model.

3) As in most R/D&I models, an innovation need not pass through each function and in the sequence implied. These functions and their varying combinations are, however, generic characteristics of R/D&I.

The two general issues to be addressed in the analysis of R/D&I functions are 1) how each function is performed and 2) the quality of integration among functions. The important considerations in addressing these issues are simply the kinds of things done, the ways in which these things get done (methods, processes, procedures), the people doing the work, the physical equipment, materials and time available to do the work, and the place or places in which the work is done. As Lawrence and Lorsch (1969) contend, the actions taken to assure that each function is performed well (i.e., differentiation, segmentation, departmentalization) create barriers to the integration of these same functions. Differentiation carried out in terms of the kinds of things done also results in differences in the way things are done, in the backgrounds and experiences of those doing the work, in the equipment, materials and time resources available, and in where the work is done. These differences create barriers to the flow of work and information among different functional groups, departments or subsystems.

Issues dealing with integration have been covered in Institutional Base (Section III), Goals Policies and Strategies (Section IV), Administrative Processes (Section V) and Information Flow (Section VIII). We will concentrate, therefore, on the issue of differentiation in the following sections, touching briefly on integration only where it seems particularly important to do so. Finally, the considerations which we will deal with in determining the state of differentiation are:

1) What is done (the function).
2) How (the ways in which things are done).
3) Who (the personnel involved).
4) With what resources (physical equipment, materials and time).
5) Where (physical and geographical location).

X. NEED IDENTIFICATION

It is generally held in the literature that something triggers the entire R/D&I process, as well as each function or even sub-function. That something we have called need identification (c. f. Kelly and Kranzberg 1975) and is related to the concepts of idea generation (Rubenstein 1963), awareness (Rogers 1962), problem perception (Robertson 1971) and need assessment (Rogers, Lin and Zaltman as reported in Zaltman and Duncan 1977). It includes the idea of technical opportunity as a source of stimulus (or trigger) in that such opportunities are seen to be responsive to actual or potential (future and generatable) needs. It will be vital to consider these two aspects of need identification. Similarly, the issues of need identification and need stimulation are closely related. Many needs "exist" simply because they have been stimulated (e.g.: by advertising). Where it is appropriate, the idea of need stimulation is to be subsumed within the more general term (as we have used it) of need identification.

While need identification is important it is also quite difficult to analyze. It may be done at all or any one stage of the R/D&I process (Kelly and Kranzberg) and, therefore, can involve a variety of persons, institutions or roles. Furthermore, the methods, processes or procedures of need identification may vary across R/D&I functions and among individuals, institutions or roles within functions. The ubiquitous, variable nature of need identification helps to explain its messy treatment in the literature and indicate the difficulties in analyzing this function. Because of its importance, however, such an analysis must be undertaken, considering at least the following issues as indicated in the Part III introduction:

A. What

Is need identification done at all stages of the R/D&I process?

Is need identification an ongoing, iterative process within the R/D&I system - - or does it tend to be "one-time" and/or "one-way".

Does the system attempt to project/predict probable/possible needs "down the road" or respond only to the "immediate," currently "pressing" needs?

Does the system intervene to generate or stimulate needs that can be satisfied by capabilities it possesses or could develop?

Are the need identification processes responsive to user demands? Do the processes attempt to create user awareness of needs?

Are need identification/stimulation processes responsive to changing/feasible technological opportunity?

Does the R/D&I system differentiate between the needs relevant to different R/D&I functions, the R/D&I system per se, and the sector served by the R/D&I system?

B. How

What are the initial need identification mechanisms?

What need identification methodologies are available? Utilized? Why and with what results? Are they appropriate? Why are some methodologies not utilized?

How do gaps in the knowledge/technology base or in the personnel or institutional bases affect need identification processes?

What are the screening procedures?

How are needs communicated (so that they lead to potential innovations)? From whom and to whom?

How are "needs" translated into "solution requirements"?

How are the various need identification processes coordinated, orchestrated, managed?

How does the system coordinate/mediate/integrate differing perceptions of "needs" (e.g.: basic researchers tend to define "needs" differently than do users)?

Have need identification processes been stable or unstable over time in terms of the institutions, personnel, mechanisms/methodologies involved?

C. Who - - Need Identifiers/Stimulators

What institutions are the primary need identifiers? Why?

Within these institutions, what organizational units or positions are the primary need identifiers?

What are the characteristics of the organizations and the personnel who are the primary need identifiers?

D. Resources

What are the resources (equipment, materials, personnel and time) devoted to need identification; to need stimulation?

Are resources formally allocated to need identification processes? To what extent are the need identification processes formalized or informal? Centralized or diffuse?

Are personnel trained specifically for need identification? Are there special-purpose need identification technologies?

Under what sorts of pressures does need identification operate?

E. Where

Are the need identification processes primarily located within a relatively few of the R/D&I system's institutions, throughout the overall R/D&I system itself, throughout the sector, or outside of the sector? Or is need identification done at all these levels?

Are the need identification and need stimulation functions integrated or differentiated?

XI. GENERATION/RESEARCH

The generation/research function encompasses what is typically called basic and applied research and is concerned with the development of new knowledge whether with or without a technical or commercial objective (c.f. Hamberg 1977, and Kelly and Kranzberg 1975).

Before looking at the types of issues or concerns involved in the generation/research function, we need to set a framework for our discussion. First, our concern here is with what may be called "disciplined inquiry" (though we do not deny the possibility that new knowledge may result by some "un-disciplined" process). Second, we use the double term "generation/research" to indicate that "disciplined inquiry" is not necessarily limited to "researchers doing formal research in a formal research setting." Thus, while our discussion below will focus primarily on formal, organized research, it will be important to know where/how/by whom new knowledge is being produced outside of the formal research setting. Third, we have deliberately avoided setting up a detailed "typology" for the generation/research function because relevant typologies appear to be context-specific. We do find, however, some usefulness in thinking of generation/research in terms of three general types of processes:

1. search (i.e., determining what knowledge already exists);

2. generation/research per se (i.e., the creation of new knowledge);

3. knowledge synthesis (i.e., the re-combination of knowledge into new forms - - which could be considered a particular type of new-knowledge production).

We are very much aware of the continuing controversy as to the utility/relevance etc. of attempting to distinguish between types of research (usually basic vs. applied -- though other descriptions can and have been used). Generally, we are avoiding the trap by not attempting to differentiate across most of the issues to be discussed. But there are questions and situations where they cannot be avoided. There, while recognizing that the real complexity is much greater than can be captured by such a typology as basic and applied, we will use these terms in essentially the following ways: "basic" as applying to research to produce knowledge for its own sake (albeit in areas of interest) and "applied" as research to produce knowledge relevant to a particular problem or issue. We are not, and we do not expect the reader to be, satisfied with this differentiation across all contexts; and the literature provides no other satisfactory and generally applicable resolution to this question.

A. What

What kinds (disciplines, areas of inquiry, basic vs. applied) of generation/research activities are there within the R/D&I system or sector?

What is the balance among search, generation/research, and knowledge syntheses processes?

What relative priorities are given to basic research (the search for knowledge "for its own sake") or applied research (the search for knowledge relevant to a specific issue or problem)? To the various disciplines involved?

Is generation/research an ongoing or periodic activity?

Is generation/research responsive to user demands? To the-state-of-the arts? To the changing technologies/methodologies?

Does "disciplined inquiry" occur outside of formal research settings? By whom? How? With what impact on R/D&I?

B. How

What methodologies tend to be used? What methodologies are the most valid, reliable and feasible with respect to the type of innovation and the sector involved?

Is the research done within a single discipline, or is it multi-disciplinary?

How is the R/D&I system's knowledge base "tied into the relevant disciplines"?

What are the information sources, channels of communication and retrieval mechanisms available for use in the search and/or knowledge syntheses processes? How adequate are they? Which ones are used or not used? Who uses them and who does not?

What are the linkages between basic and applied research within the R/D&I system? Between researchers? Between research organizations? Between disciplines? Between R/D&I systems? Are there gaps? Are existing linkages used? If not, why not? By whom?

What competitive dynamics and patterns are involved in the research function (e.g.: status; proprietary rights)? Involving what researchers or research organizations? Are there problems of secrecy?

C. Who

Is research being done by individuals or by teams; within individual institutions or in cross-institutional settings; etc.?

What kinds of institutions are involved: public/private; profit/not-for-profit; university/industry/R&D organizations/government; etc.? Where are the "centers of excellence"? Which are developing?

Who controls decisions concerning funding of research; setting of research priorities? What is the role of users in the setting of research priorities?

D. What Resources

What is the level of resources (equipment, material, personnel) devoted to generation/research? By area of inquiry? By discipline? By process (search vs. knowledge synthesis vs. generation/research)?

What is the available knowledge base? How is it changing?

What is the level of maturation of the knowledge base and of the research function in a specific R/D&I system?

Are personnel trained specifically for generation/research? Are there special purpose generation/research equipment, machines and supplies, methodologies?

Within what sorts of time pressures does generation/research operate?

What stability of funding, institutions, personnel is needed? Does this differ across R/D&I sectors or in terms of particular types

of innovation? What has been the pattern of such stability? What level of stability can be projected for the future?

What is the rate at which the research function can be built or expanded?

E. Where

Are generation/research activities located within a relatively few institutions, throughout the R/D&I system itself, throughout the sector, or outside the sector? Or is generation/research done at all these levels?

Are these institutions independent or embedded within operating organizations (or both)? If the former how autonomous are they?

To what extent are research activities centralized or decentralized with the sector/the operating institutions?

XII. DEVELOPMENT

The development function is that part of knowledge production which takes existing knowledge and transforms it into a form or format which can be utilized by users (c.f. Hamberg 1966, and Kelly and Kranzberg 1975). Development is often understood as beginning where research stops and ending when the development output is ready for production or use. In practice linkages to the research function may be weak, and there may or may not be a clear separation of the development and production and implementation/utilization functions.

A. What

Is the intended development output simple or complex; large scale or small scale; expensive or inexpensive? What mix of technological skills is required?

What are the implications of the nature of the product on: the nature of the development process required; the type, mix and number of personnel required; the feasibility of pilot testing, evaluation?

What support materials (e.g.: instructional manuals) must be developed? What support services (e.g.: maintenance) will have to be provided?

At what point is the development output ready for initial field testing? At what point has the development output been sufficiently tested to permit production, dissemination and utilization?

Are developers creating development outputs which are in fact "out-of-date" because the state of the art permits superior outputs to be developed?

What are the product and process design requirements? Engineering requirements?

B. How

Is the development process being done in clear and separate steps? What decisions are made in this process?

What steps are or are not needed? Are any "needed" steps being omitted or done inadequately?

How and what kind of quality control is done?

To what extent (and in what ways) does the developer seek and receive additional information from users during various stages of the development process? What are the communication linkages between developers and producers?

Do the developers provide support services to producers? To users? What kinds of support services?

What is the extent of clarity and certainty in process of need identification (for development outputs)? Can users clearly specify what they need? Do developers know exactly what users mean? Is the developer then able to say with assurance to the user: "This development output is what you asked for"? Is it then obvious to users what to do with the development output?

To what extent is it relevant to focus development on technological opportunities (i.e., in the expectation that once developed, the output will be seen by users as "needed")? To what extent do the developers attempt to "forecast" potential user "needs" for development outputs based on technological opportunities? How

is such "forecasting" done? By whom (i.e., by the developers; by use of consultants; by producers, by marketing departments; etc.)?

To what extent is the development process stimulated by/informed by research activity and scientific knowledge as opposed to being self propelled by the state-of-the-developmental-arts?

C. Who

Is development being done by specialized development or R&D organizations, by a development department of an organization, or by users?

What organizations are doing development? Are they: private or public; profit or not-for-profit; large scale or small scale; sector-specific or sector-spanning? What is their commitment to the sector?

What is the range or mix of development outputs on which the development organization works?

Who does/should do evaluation of development proposals, projects, outputs - - i.e., what should be the evaluation role of developers, users, researchers, funding agencies, etc.?

D. Resources

What level of resources (equipment, materials, personnel and time) are needed/devoted to development?

What are realistic time lines for development? What affects the time line (e.g.: nature of the output; availability of personnel, funding, supplies; laws and regulations; etc.)?

What kinds and what levels of skills and technical sophistication do the developers need to have in relation to particular types of products (development outputs) being developed? What kinds and what levels of technical sophistication do the various developers currently have?

Is testing feasible? What does a test prototype cost? Are required technologies and facilities available? Are the criteria for evaluation simple and clear cut or complex and hard to define?

What constraints are there in relation to development outputs (e.g.: existing manufacturing facilities and technologies cannot produce the development output; cost of modifying or replacing existing equipment; legal regulation; social pressure; etc.)? Are developers aware of/responsive to such constraints?

To what external influences are the developers most vulnerable (e.g.: high dependence on government funding in general or in relation to a particular set of governmental agencies; fluctuations in priorities given to their particular areas of developmental concerns; etc.)? Are the developers flexible/adaptable in terms of their areas of focus, the clients whom they serve, their mix of technological skills, the changing social/legal/economic/political environment, etc.?

E. Where

Are developers many or few? Centrally located or geographically dispersed? Located within institutions performing other functions or in specialized institutions?

XIII. PRODUCTION

The production function is a critical R/D&I function within the overall flow of innovation from knowledge production to knowledge utilization. A central issue is whether or not the production function can handle the results of R&D (Abernathy and Townsend 1975). Thus, to do research and development without considering whether or how the R&D outcome can/will be "produced" is to risk slowing down the translation of innovation from knowledge production to knowledge utilization -- or even (at worst) to risk making R&D outcomes meaningless in relation to utilization (Havelock 1969, Zaltman and Duncan 1977).

In addition to the impact the production function can have on the overall R/D&I process, we may note that the designing of production systems is a process of innovation itself. Further, we also sometimes find the development function occurring within the production function as efforts are made to adjust production to R&D outcomes. Also, we must take note that in some sectors of fields of knowledge, no clearly differentiated production function is visible, but rather it is embedded in a development function. This is most common where the product of the R&D system is a procedure or a new perspective requiring only some form of communication (an announcement or a paper) for the innovation to be disseminatable. In these cases the production requirements can become trivial and able to be handled from within development. This is not to be taken as ignoring the importance of such production functions as publishing, T.V. production, etc., which do represent differentiated production functions.

A. What

The issue of "what" is produced involves a description of the innovations. This is dealt with under Feature IX: Innovations.

B. How

What are the products or processes produced? Are they simple or complex? Large or small? Evolutionary or radical changes from existing products or processes?

What is the scale and scope of production processes?

Is production done in single or multiple unit processes? Are these continuous or separate? To what extent does the work of one production unit affect another?

How must the product be designed so that it can be produced with existing facilities and equipment? In order to meet specifications? In order to reduce costs? What relative emphasis is to be placed on cost vs. quality in product design?

What are the engineering requirements of production in relation to the nature of the product and the facilities/equipment involved?

What are the requirements for designing the production system (e.g.: building facilities)? How is this designing done? By whom?

What are the requirements for production planning and control (e.g.: how many are to be produced in what order)? How might such requirements constrain the production of new innovations. What methods are used?

What kinds of production operations are called for (e.g. : automation, assembly line, continuous process, intricate/sophisticated vs. unskilled operations, etc.)? What kinds of in process (materials handling) transportation are needed?

How is quality control done? How rigorously?

Can parts of the production process be subcontracted? Are they? Which parts?

Are production techniques and facilities relatively "fixed" - - or are they adaptable and flexible? How is adaptability/flexibility affected by the nature of the technology; by the scale/scope of production requirements and costs?

How does the nature of the materials involved affect production? Are the materials reactive? Are the materials easy or difficult to work with? Do they have to be transported, stored? Do they have to be transformed?

How is the choice of production technologies influenced by the availability/cost of labor, materials, energy sources, transportation, etc. (factor endowments -- in economic terms). What are the implications for the "appropriateness" of various technologies?

C. Who

Is production being done by specialized production or from written R&D organizations, by a production department of an organization or by a separate user organization?

What organizations are carrying out the production function? Are they: private or public; profit or not-for-profit; large, medium or small scale; sector-specific or sector-spanning? What is their commitment to the sector?

Who chooses the producers? How?

D. Resources

What level of resources (equipment, materials, personnel and time) are utilized in production?

Are specialized personnel required? Is cooperation among personnel required? Are personnel available? Are there any special personnel constraints that could affect production (e.g.: union regulations)?

Are the production processes of sufficient scale or scope to meet the requirements imposed by a specific R&D product or to produce sufficient quantities to meet user needs?

What are the technological characteristics of production techniques and facilities? Is the available technology appropriate and adequate? Is it "in place"? Does the production process require sophisticated technology or relatively simple technology?

What is the rate of change in the development of new production technology?

What are the time pressures involved? Is obsolescence a significant problem?

What costs are involved? Does production require large or small scale capital, operation and/or maintenance costs? Are there any special patterns of cost expenditures to be considered?

E. Where

Are producers centrally located or geographically dispersed?

Are there any special regional, local/state, or international requirements or patterns?

Are there any requirements to place producers near users, materials sources, energy sources, transportation links, etc.?

XIV. MARKETING/DISTRIBUTION/DISSEMINATION/DIFFUSION

An R/D&I system comprises all the functions related to knowledge production (KP) and knowledge utilization (KU). For R/D&I to comprise a complete system, there must be a "bridge" over which the work done in knowledge production can be "sent" to users -- or, conversely, over which users may come to "find" results of knowledge production which are useful to them (c.f. Robertson 1971, and Zaltman and Duncan 1977). Similarly, there must be such a two-way bridge for knowledge production personnel to learn about user needs and for users to communicate their needs to knowledge production personnel.

Such KP-KU linking activities may be (and are) described variously. Although no single descriptive term would likely be adequate to describe all such KP-KU linking activities, the following four terms or categories reasonably well capture the types and broadness of KP-KU linking activities: marketing (which is a producer-oriented description); distribution (which implies the methods by which and the extent to which KP results are made available to users); dissemination (which has a more general, broad information flow connotation); and diffusion (which implies a less proactive process than the first three terms). We recognize, of course, that these are not completely discreet concepts; that, indeed, they overlap significantly; and that the terms are often times variously defined by various people. We also emphasize that these KP-KU linking processes include both user-user and KP-KU communications (Havelock 1969, and Zaltman and Duncan 1977).

A. What*

What are the marketing, etc. implications of the products being simple or complex? Of there being many or few products? Of the products being "hard" or "soft"?

*See also Feature IX: Innovations.

Are the products reactive to their processes of marketing/distribution, etc.? (For example, acids react with some containers but not others; educational R&D products may become modified by the way they are promoted and disseminated to teachers and students.)

How do product characteristics affect the requirements for marketing/distribution/dissemination/diffusion mechanisms and systems?

What are the implications of there being a small vs. large "mix" of product types?

B. How

What kind of mechanisms, methods, systems are most appropriate in relation to specific types of products and/or to specific types of users?

What is the level of user trust in relation to the product, the producer, the marketing/distribution/dissemination/diffusion system?

Under what conditions would different methods be considered cost/effective?

What methods and channels are being used? Are not being used? Why not?

Are there alternative channels, or are users dependent on a single linkage to knowledge producers? If so, what happens if it "fails"?

Are various channels inter-connected or fragmented?

Is the marketing/distribution/dissemination/diffusion system user-driven (i.e., essentially controlled by users) or user-oriented (i.e., while user input is taken into account, their input is not determinative)? What mechanisms are used to "stimulate user demand"?

What is the level of R/D&I system maturation? How does this affect the need for/relevance of different marketing/distribution/dissemination/diffusion methods and approaches?

What linkages exist between the marketing/distribution/dissemination/diffusion on the one hand and researchers/developers/producers/users on the other? Are there significant "gaps" in the system?

What mechanisms are used in marketing/distribution, etc., for quality control, storing, retrieval, packaging, and tailoring?

What role is played by intermediary linking organizations or personnel?

C. Who

What types of organizations are involved in marketing/distribution/dissemination/diffusion within the R/D&I system or in relation to a particular KP output or set of KP outputs (e.g.: private or public; profit or not-for profit; producers/users/intermediaries)? What are their respective roles? What is their level of professionalism? What is their commitment to a particular sector?

What are the characteristics of these organizations (e.g.: large or small; sector-specific or sector-spanning; level of maturation; stable or unstable; etc.)?

What are the implications of there being many potential users, or only a few? Of users being aggregated or diffuse?

What are the implications of there being many potential users, or only a few?

Are the potential users relatively homogeneous or heterogeneous in terms of: needs, interests, acquisition/implementation/utilization capabilities, geographic location, type of organization, etc.?

What are the entry points into the user system? Who will make the acquisition decisions? Will these be different in different product types?

What are the typical user patterns of adoption of innovations?

What contextual constraints are there in the user system (e.g.: lack of resources to acquire; burdensome funding or bidding requirements; low level of selection/testing/evaluation or implementation/utilization capabilities)?

What level of awareness do users have about a product; about their need for a product?

Is it relatively easy or difficult to identify which users are the relevant potential target population? To identify/define the needs of various users?

What motivational constraints do the users have in terms of motivation to study, test, evaluate, implement and/or utilize a product (e.g.: time constraints, training requirements, prior bad experiences, etc.)?

What effects do the above considerations have on requirements for marketing/distribution/dissemination/diffusion mechanisms and systems? On policies and strategies?

Who monitors the marketing/distribution/dissemination/diffusion mechanisms and processes?

D. Resources

What level of priority and resource commitment is given to marketing/distribution/dissemination/diffusion?

Are there special marketing/distribution/dissemination/diffusion skills required? Special materials? Equipment?

What are the time pressures involved?

E. Where

Is marketing/distribution/dissemination/diffusion centrally located or geographically dispersed? In relation to research? In relation to users?

XV. ACQUISITION

Acquisition has been generally considered as the end point of most models of the R/D&I process, but is far more broadly conceptualized in the CISST model. Existing models of the innovation-decision process are, furthermore, based on the individual as decision maker (Rogers and Shoemaker 1971), whereas we recognize the importance of dealing with it at organizational as well as individual levels.

Acquisition processes in organizations are conceptually less precise than individual processes (March and Simon 1958). Acquisition decisions can and do occur at almost any or all stages of the knowledge utilization process and, for that matter, can be reversed later on. There are a variety of different individuals and groups potentially involved in these various decisions, and decision making need not always be formal. In short, the organizational innovation-decision process is dynamic, complex and stochastic in nature (c.f. Zaltman, et al. 1973) and therefore difficult to analyze.

A. What

What are the steps in acquisition processes? What defines/describes an acquisition in different contexts?

Are users aware of their needs or "performance gaps"? And does this lead them to search for innovations or do innovations create needs?

Are bids used/required for innovations?

Is testing done before purchase?

Is the evaluation formal or informal?

Is purchasing formalized (purchasing agent or department)?

Is the acquisition process relatively simple or complex? Centralized or diffuse?

B. How

In what ways do users become aware either of their needs or of innovations (e.g.: from need surveys; pressure from the environment; critical events; publications; informal communications; meetings; marketing efforts of producers; etc.)?

How extensive is the search for innovations?

What is the bidding process? Does it exclude any potential suppliers?

Are the budgeting and bidding processes flexible or rigid? What time lines are involved in budgeting and bidding processes?

How extensive is the testing of innovations by acquirers? What are the rating criteria used in such testing?

On what basis are purchase decisions made? What are the rating criteria used in purchasing?

Are there any kinds of cooperative purchasing/leasing arrangements between institutions, between agencies of a level of government (e.g.: police and fire departments) etc.?

To what extent is the acquisition process formalized? Which steps?

What laws/regulations or organizational policies/regulations affect the acquisition process?

C. Who

What types of individuals or organizations are the users of the innovations (private/public; profit/not-for-profit/non-profit; large, medium or small; sector-spanning or sector-specific; etc.)?

What personnel within user organizations are involved in/have authority over: the setting of criteria for testing, evaluation, purchasing; deciding what is "needed"; making purchase decisions; etc.?

What are the roles of: producer personnel; intermediate agency personnel (vendors, professional associations, disseminators, "clearinghouses", etc.); "product champions"; and user personnel (purchasing agents, engineers, higher level decision/policy makers, users of the innovations)?

Are the personnel who make purchasing decisions different from the personnel who will utilize the acquisition? Would the personnel who would utilize the acquisition be capable of making technical evaluations? Do purchasing personnel use different acquisition criteria than do the personnel who would utilize the acquisition? How are such differences resolved? With what effect on acquisition decisions (in terms of the value of the acquisition to the personnel who must use the acquisition)?

D. Resources

What is the level of resources devoted to acquisition processes?

What are the technical resources (e.g: for testing) of user organizations? In relation to the requirements of the innovations? Are these resources adequate?

To what extent are specialized personnel required for need assessment, search, test, evaluation, purchase, etc.? Activities? Are these personnel available?

Are special purpose materials or equipment required for any or all of the steps of acquisition? Are these materials or equipment available?

What are the time pressures involved?

What are the intraorganizational linkages (e.g.: between user personnel, engineers, purchasing agents)? What are the interorganizational linkages (e.g.: between producers and user organizations)?

E. Where

Are user organizations (and testing organizations, etc.) centrally located or geographically dispersed? In relation to producer organizations? Research organizations?

XVI. IMPLEMENTATION/UTILIZATION

Implementation/utilization also tends to be ignored in most models of R/D&I processes. These stages of subprocesses begin after users have actually purchased or acquired an innovation or developed it themselves. In this last case development may occur conveniently with implementation/utilization. It is important to note that there are significant qualitative differences between implementation and utilization. Implementation is the initial use or installation of the innovation. Rogers and Agarwala-Rogers (1976:163) describe installation as "the process of connecting the innovation to the ongoing structure and activities of the organization." Utilization refers to the continued, sustained use of an innovation which is in essence "the process of removing the status of innovation" (Rogers and Agarwala-Rogers).

While there is little merit in trying to delineate precisely where implementation ends and utilization begins, there are some significantly different dynamics between the two. For example, during implementation, the user is dealing with a relatively new phenomenon; during utilization, the innovation becomes "familiar". Indeed, failure during implementation may prevent (or at least set a negative "tone" for) sustained, continuing utilization of an innovation.

At the same time, however, many of the relevant issues are very similar, and it is for this reason that implementation/utilization is considered here as a single function. With an awareness of both the differences and similarities between implementation and utilization, the researcher or policy/decision maker can determine (in a specific instance) the extent to which implementation and utilization may be considered simultaneously or need to be considered separately.

The items below illustrate the kinds of issues relevant to implementation/utilization.

A. What

Have innovations been accepted within user organizations on a continuing, sustained basis? Has innovation been "institutionalized" (i.e., has it become basic/essential to user organizations, or has it remained peripheral)?

Are innovations utilized in stages? Is testing needed? Are trial runs needed?

In what ways can/will innovation and usage be extended to improve over time? What will be required? Will innovations be utilized in stages?

Does testing "destroy" or "use up" innovations? Can non-destructive methods (e.g.: simulation) be used?

What are the user's relationship with the producer? Is the user dependent on the producer? In what ways? Are alternative sources (producers) available to the user? Is the user aware of these alternative sources? If not, why not? Does the user "favor" one source over another? If so, why and with what effects?

B. How

How is usage of innovation instigated, routinized and standardized?

What are the processes for monitoring, evaluation, modification? For de-bugging? For trial runs?

What are the processes for providing innovations with maintenance and support services?

What will be the influence of institutional structures and resources on how implementation/utilization takes place? For example, are required liaison functions in existence? Technical service functions?

What is the effect of innovation source? Of implementation strategy?

How are innovations adjusted or altered for and during usage in specific settings?

C. Who

Who and what types of organizations or individuals are users? (private/public; profit/not-for-profit/non-profit; large/medium/small; sector-spanning/sector-specific, etc.).

Who are the key user personnel? With respect to what aspects of implementation/utilization? Who are the user change agents and opinion leaders?

Does innovation provide status for user organizations or organizational departments or personnel? Is there professional status associated with innovation?

Do organizations including the producer help the user implement and/or service the innovation? What organization?

Who/what user activities are/will be affected by innovations? In what ways? What organizational changes are/will be needed?

What is the history of innovation in the user system: How do these differ between organizations and within specific organizations? Is innovation diffused throughout the system or is it utilized in only a segment? If the latter, why?

In what ways does innovation require or allow expansion of an organization's capabilities, facilities, support services, etc.? What does innovation replace in terms of previous technology, equipment, personnel, etc.?

What actual or potential conditions tend to affect the acceptance or rejection of the innovations?

D. Resources

What capabilities do users need for implementation/utilization? Do they have or lack such capabilities? Which user organizations and/or personnel? With respect to which aspect of implementation/utilization processes?

What is the scope of activities and system adaption required? What resources are needed? What level of technological sophistication is required? For what technologies?

What training of user personnel is provided? What preparation must be made for support services such as accounting, computer programming? What supplies must be ordered? Are organization development activities needed to prepare for implementation?

What costs are involved in maintenance? What support services, personnel, training of personnel must be provided for maintenance?

What need does the user have for producer help in implementation/utilization?

What is the capability of the producer to provide such help (e.g.: the producer's ability to train user personnel; the producer's technical capabilities)?

What is the willingness of the producer to provide such help? What incentives does the producer have? Does the producer provide such service as a standard procedure? Is the particular situation of special importance to the producer?

What are the incentives and/or barriers for users in the process of innovation? What are the "entry points" for innovation?

E. Where

Are user organizations (and testing organizations, etc.) centrally located or geographically dispersed? In relation to producer organizations? Research organizations?

XVII. SUPPORT SERVICES

A basic tenet of the planned change literature which somehow has tended to be ignored in models of innovation is the provision of services in support of innovation (Argyris 1970). While the need for support services will be relevant (though different in specifics) for all of the R/D&I functions, the need generally seems to be greatest in support of implementation/utilization (Doctors 1969).

A. What

What are the R/D&I system's requirements/needs for support services (e.g.: protection of proprietary rights; testing and analysis; equipment; supplies; transportation; computer services; maintenance services; training; etc.)?

How do these requirements/needs differ according to level of system maturity, R/D&I function, R/D&I institutions, type of innovation involved, etc.?

What services are the R/D&I system or institutions unable to provide for themselves? What services should they not provide for themselves? Why Not?

How dependent are the R/D&I system or institutions upon the support services? What are the effects of such dependence?

B. How

What combination of rent/buy strategies (for obtaining support services) are most appropriate at a particular time, under existing conditions, for a particular type of support service or innovation, etc.?

What linkages exist between the R/D&I system/institutions and the required/needed support services?

What gaps are there? What is the impact of these gaps?

What barriers/constraints to linkage exist (e.g.: legal constraints; slow payment by public agencies for services received; support service system not being interested in the particular R/D&I system or section)?

C. Who

What are the sources of support services? Are there alternative sources from which to choose? If so, what are the significant differences between them?

D. Resources

What level of sophistication and/or specialization is required in the support services?

To what extent are the required/needed support services available or not? Are there significant delays in obtaining support services?

What is the level of technical capability of the support service systems?

What is the quality of support services available?

What level of resources are devoted to support services?

E. Where

What is the location of support service agencies in relation to their client organizations?

XVIII. EVALUATION RESEARCH

The evaluation research function is often simply called "evaluation". We have deliberately chosen to use the term "evaluation research" to indicate that while evaluation is done in relation to knowledge utilization, there is a research/knowledge production component to evaluation. Thus, while evaluation research is done to inform funders, policy makers, decision makers and managers, it does create knowledge which (in turn) expands the knowledge base for R/D&I (Zaltman and Duncan 1977).

Evaluation research may be either of two basic kinds (c.f. Forrester 1968). On the one hand, it may be done for the purpose of providing policy/decision makers with data on which they may base decisions to continue, discontinue or modify a program, project, etc. - - or simply to "evaluate" the effects of a program/project. In either case, the focus is on "end results", and the evaluation research would usually be done only after a significant period of time had elapsed since the beginning of a program, project, etc. - - e.g.: upon the completion of a program, project, etc., or at some regularly scheduled, but fairly long, intervals (e.g.: annually). This kind of evaluation research is often called "summative".

On the other hand, evaluation research may be done on an ongoing basis during the life of a program, project, etc. Here the purpose is to provide managers with data upon which "mid-course", operational changes can be made as needed. This kind of evaluation research is often called "formative".

There are potential conflicts between the two types of evaluation research. In summative evaluation research, premium would usually be

placed on avoiding input which could alter the program, project, etc. - - in order to avoid "contaminating" the research process. In formative evaluation research, however, premium is given precisely to inputs which would allow such alterations. Similarly, the research designs tend to be different for these two types of evaluation research.

A. What

Which kinds of evaluation research is being done?

What are the objectives of proposed evaluation research? Which kind of evaluation research is needed to accomplish these objectives?

What are the implications for evaluation research if the focus of evaluation is short-term as compared to long-term? If the focus is on consequences related to the immediate user as compared to consequences related to society?

What is the nature of the programs or projects being evaluated (e.g.: large or small scale; number and type of people involved in or affected by; level within system; social service or physical science based; length of time before "results" can reasonably be expected; etc.)?

Are the goals/objectives of the programs or projects clear?

In what ways and to what extent does the nature of the programs constrain the feasibility, reliability or validity of evaluation research?

B. How

What methodologies are used for evaluation research?

To what extent are the methodologies validated, replicable? In what fields, disciplines, sectors? To what extent does the nature of the program or project (or the situational context) constrain validation and/or replication?

What are the criteria upon which evaluation will be made?

How are the evaluation criteria developed?

Have potential conflicts in data interpretations, usage of results and access to results been identified prior to designing the evaluation research process? If so, how will these considerations be built into the design process; and/or what steps will be taken to deal with the potential conflicts?

If both kinds of evaluation research are done, can they be done within the same research design, or must the research designs be different? Would the research evaluators who do the formative evaluation research be able to be objective about the summative evaluation research?

What are the similarities, differences and/or conflicts between methodologies for formative and summative evaluation research?

At what points in the evaluation research process should formative evaluation be undertaken?

Can direct "measurements" of outcome be obtained (or can they be obtained only after long periods of time)? Are "secondary" or "predictor" indicators available? With what degree of reliability and validity?

C. Who

Who are the significant participants (e.g.: the evaluation researchers; funders; policy makers; decision makers; managers; staff; external political or pressure groups)?

At what levels or in what parts of the system are the participants located (e.g.: local, state, federal levels of government; top level managers; functional managers)?

What are the information needs, perspectives, "vested interests", objectives, roles of the participants? To what extent and in what ways are these perspectives, etc., different or in conflict?

What is the nature and history of the relationship between the participants (e.g.: collaborative, conflictual, none, etc.)?

Who controls the problem definition (i.e., decides what is to be researched and evaluated)?

Who determines what criteria and methodologies are to be used?

Who determines whose information needs will/will not be met?

Who has access to the evaluation research results? Who determines access?

Who determines how the evaluation results will be used?

What is the role of the evaluation researcher in determining problem definition, criteria, and access to results?

D. Resources

What skills do evaluation researchers need to have? Do these skill requirements differ for the design, data gathering, data analysis and data reanalysis stages? In terms of types of innovations? Do the skill requirements differ between formative and summative evaluation researchers?

What is the training and background of the evaluation researchers?

What is the level of resources devoted to evaluation?

Are special materials or equipment needed? Are they available?

E. Where

What is the geographical or physical location of "evaluations" in relation to their clients?

PART FOUR

RESEARCH ON R/D&I

XIX. RESEARCH ON R/D&I

As the literature cited in this report indicates, there is a large and growing research effort and community of scholars concerned with R/D&I. Much of this research has centered on industrial research in the U.S. and Western Europe (c.f. Rubenstein 1963), but in recent years there has been increasing diversity in terms of R/D sectors or systems studied, methodologies utilized, etc. (c.f. Rogers and Agarwala-Rogers 1976, and Zaltman et al. 1973) which provides a research base for the study of particular sector or system and cross sector or system analyses. The kinds of research pertinent to the contextual analysis framework would include policy research/policy analysis done for an R/D&I system institution, research on any of the R/D&I features, research on R/D&I systems in general, contextual analyses relevant to particular R/D&I systems, and research on research (R^2).

Some important issues in analyzing available research on R/D&I could include:

Control - - who determines what research on R/D&I will be done, how it will be done, who has access to data findings, how findings will be used?

Focus - - On what aspects of R/D&I does the research focus?

Methodology - - What methodologies are used? What are the strengths and weaknesses of the methodologies?

Scope - - Is the research narrowly or broadly focused?

Generalizability - - To what extent are the implications of the findings generalizable?

Institutionalization - - Are there research organizations or departments which focus on research on R/D&I? Or is the research on R/D&I being done by individual researchers or small research teams apart from any institutionalized base? Is research on R/D&I done on a continuing or on an occasional basis?

Developmental state - - For what aspects of R/D&I is research at a high or low level of development?

Literature base - - How adequate is the literature in regard to the empirical and theoretical bases for research on R/D&I? What information do we have about R/D&I? How valid and reliable is the information? What "gaps" exist?

Utilization - - How have research findings been used (or not used)? Why or why not? By whom?

Impact - - How have the research findings affected R/D&I systems? What are the implications of the research findings for R/D&I systems? For functions or aspects of R/D&I systems?

Control - - Who determines what research on R/D&I will be done, how it will be done, who will do it, who will have access to findings, how findings will be used?

R^2 - - What research is being done (and by whom) about the nature and process of research on R/D&I?

The Research on R/D&I Community - - What is the need for encouraging the development of the communities of researchers on R/D&I? How might this best be done in order to balance both short term and long term impact?

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